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THE

BRITISH CELESTIAL ATLAS;

BEING

A COMPLETE GUIDE

TO THE ATTAINMENT OF A

PRACTICAL KNOWLEDGE OF THE HEAVENLY BODIES:

CONTAINING

TWELVE ROYAL QUARTO MAPS;

OR

ENTIRE VIEWS OF THE STARRY HEAVENS,

AS THEY APPEAR TO THE NAKED EYE;

ADAPTED

FOR EVERY NIGHT THROUGHOUT THE YEAR:

ON WHICH ARE CAREFULLY LAID DOWN, ALL THE STARS VISIBLE IN THE BRITISH EMPIRE, FROM THE FIRST TO THE FOURTH MAGNITUDE; WITH THE BOUNDARIES OF THE CONSTELLATIONS ACCURATELY DEFINED.

ALSO

THREE MOVEABLE PLATES, AND A PLATE OF DIAGRAMS,

TO ELUCIDATE THE

Motions of the Earth and the Celestial Bodies:

ACCOMPANIED BY A

FAMILIAR TREATISE ON ASTRONOMY.

By G. RUBIE,

TEACHER OF GEOGRAPHY, THE USE OF THE GLOBES, ASTRONOMY, AND NAVIGATION, HASTINGS.

LONDON:
BALDWIN & CRADOCK, PATERNOSTER ROW; G. WOOLL, AND THE AUTHOR, HASTINGS;
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ERRATA.

Page 8, col. 1, and page 23, line 1, *for* Madusa, *read* Medusæ.
—— 8, col. 2, and page 22, lines 23 and 27, *for* Madusa, *read* Medusa.
—— 23, line 6, and page 37, line 22, *read* Medusa.
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Plate, July, *for* Alderamin, *read* Alpirk, *and vice versa.*

INTRODUCTION.

The general division of the Heavenly Bodies is that of Fixed Stars, Planets, and Comets. The Fixed Stars are supposed to be Suns, placed at immense distances from the Earth and from each other. Planets are either primary or secondary; the former revolve round the Sun, and the latter, called Satellites, revolve round their primaries. On the nature and design of Comets, various opinions exist; but they appear to be a compound of the other two; participating of the nature of the Sun, as to the quality of their Atmospheres, and that of the Planets, with respect to their motions. Hence they may be very properly termed Secondary Suns; and are doubtless destined to some noble purpose, with which we are yet unacquainted.

The Planets and their attendant Satellites, are undoubtedly of the same nature as the Earth, and destined for similar purposes. For they are solid opaque spherical bodies, and appear to be capable of vegetation, and the support of animal life.

Some of them are many times larger, some smaller, and others about the size of the Earth. The Satellites, as before mentioned, circulate round their primaries, and with them, round the Sun, like the Earth and Moon, in longer or shorter periods, according to their respective distances from him; and have, where most convenient, a regular return of Spring, Summer, Autumn, and Winter.

They have, therefore, warm and cold climates, requisite for the production of various sorts of vegetables; and in such as have afforded opportunities of discovering it, are observed to have a regular rotation on their own axis, like that of the Earth; causing an alternate return of Day and Night.

If, therefore, we reason from analogy, we must certainly conclude that each Planet is inhabited with a race of intelligent beings, on whom the all-wise Creator bestows his blessings suitably to their respective wants.

The number of the Fixed Stars is found by the telescope to be infinite, some of which are observed to revolve round others, or round a common centre of gravity; forming, as it were, Systems of Suns. Those which have not such a motion are supposed by Dr. Herschel to be surrounded with Planetary Systems, similar to our own; teeming with life and vegetation.

Astronomy, therefore, surpasses every other science in the sublimity and grandeur of the objects which it contemplates. The magnificent appearance of the Celestial Bodies, the regularity and harmony of their motions, combined with the various phenomena they display, strike us with astonishment and profound admiration!

There is no art or science whatever, so well calculated to improve and elevate the human mind, to give us so just conception of ourselves, and to excite in us such exalted ideas of our beneficent Creator, as that of Astronomy.

If we consider the science only as connected with our commercial pursuits, we shall find it to be one of the most useful and important branches of knowledge. For by observations made on the Sun, Moon, and other Celestial Objects, Astronomers and Mathematicians have been enabled to ascertain the form and magnitude of the Earth, and to lay down on Maps, Charts, and Artificial Globes, with an astonishing precision, the situation and extent of every Country, Kingdom, and known place on its surface.

By the assistance of these Charts, combined with Solar, Lunar, and Stellar observations, it is that the bold and adventurous Mariner is enabled to prosecute his voyage through the wide and pathless ocean, from one port to another, with certainty and safety.

Thus we find that it is by the knowledge we derive from Astronomy, that trade and commerce is carried on to the remotest parts of the Earth; and the luxuriant produce of foreign climes, imported and distributed for our health, comfort, and convenience.

Astronomy being now very justly considered as forming an essential branch of a liberal education, he who endeavours to render the attainment of so useful and sublime a science not only easy, but in many instances to convert the very means of obtaining it into an amusement, ought to meet with encouragement from an enlightened public, in proportion to the advancement he makes towards the accomplishment of so desirable an object.

The arrangement of the work, in which much original matter will be found, is that which experience as a teacher has suggested; beginning with a general view of the whole Starry Heavens, their classification, and origin of the figures by which they are designated. A short description of the artificial Globes follows; after which the Student is instructed in the knowledge of the Earth, its form and magnitude, and the methods by which they have been ascertained.

The apparent diurnal motion of the Sun, Moon, and Stars round the Earth from East to West, is next explained, and proved to be occasioned by the rotation of the latter on its axis in a contrary direction. The apparent motions of the Celestial Objects being different when viewed from other parts of the Earth, these phenomena are more fully and separately illustrated by Problems on the Moveable Plates of the Celestial Globe; to which are added several other useful and interesting Problems, all of them being easily performed on the same Plates.

The details of the Solar System comprehend, it is presumed, all that is most interesting in that department of the science; notes are also added, in which the magnitudes, velocities, &c. of the Planets are calculated.

In the description and use of the third Moveable Plate, which may be called a Manual Planetarium, the apparent motion of the Sun in the Ecliptic; the cause of the appearance of certain Fixed Stars at different hours of the Night, and at different times of the Year; the Seasons; Long and Short Days: Polar Day and Night; the Precession of the Equinox; the real and apparent motions of the Planets; their Direct, Retrograde, and Stationary appearances; the inclination of their orbits to the plane of the Ecliptic; their Nodes, Latitude, &c. are all familiarly illustrated; including a very instructive and amusing practice, with rules and examples for representing the position and phases of the Earth, Moon, and Planets for any given day. Then follows the Eclipses of the Sun and Moon, illustrated by suitable diagrams.

The Military Orrery, or New Astronomical Game, is introduced for the use of Schools and Families, by which they may be instructed and thoroughly grounded in the knowledge of most of the principles and phenomena explained in the Solar System; while the means of acquiring it, will afford them a fund of novel and rational amusements.

In the general description and use of the Maps, a bare inspection of which, it is presumed, will be sufficient to prove their utility, rules and examples are given for ascertaining the places of the Moon and Planets thereon, for any day in the year; consequently they will not only represent entire views of the Fixed Stars, but of the Moon and Planets also. As fresh Constellations appear every month on the eastern part of the Maps, while others are disappearing on the western part, the relative situation of the whole of the Constellations visible to the British Islands will thereby be obtained.

The monthly observations will direct the Student how to find all the principal Stars and Constellations; and after having acquired a knowledge of them, those of less note may be found by their relative situation with the others. In this department, numbers are annexed to the names of the Stars, for the convenience of nautical and other persons, who ascertain the Latitude and Longitude by Stellar and Lunar observations. The numbers correspond with those prefixed to the Stars used by Mr. Thomas Lynn in his excellent "Star Tables;" which are now coming into general practice. The names of the principal Stars on the Maps will also be found to correspond generally with those inserted in Table XIV. of Mr. J. W. Norie's, and Table XX. of Mr. J. H. Moore's Epitome of Navigation. If mariners were to take the pains to learn those Stars by means of these Maps while they are within the parallels of 48° and 53° north Latitude, they would be sure to know them when seen from any other part of the world.

Thus in one book are comprehended, a Familiar Treatise on Astronomy; two Moveable Plates of the Celestial Globe, with Problems thereon; a Manual Planetarium, on which a variety of instructive and amusing experiments may be performed; and a complete Atlas of the Starry Heavens; which it is hoped will be found equally useful to Families, the Conductors of Schools, private Students, and to Mariners.

Hastings, October 4, 1830.

A

GENERAL VIEW OF THE UNIVERSE.

Astronomy may be defined to be the Science by which we are taught the knowledge of the Heavenly Bodies, the Sun, the Moon, the Planets, the Comets, and the Fixed Stars: with a judicious account of their Order, Distances, Magnitudes, Periodical Revolutions, and Eclipses; the Laws which govern the Heavenly Host, and by which their several courses are directed; as also of the cause of their apparent motions in the Heavens, as seen by a Spectator on the Earth.

The Science is naturally divided into two parts; namely, Geocentric and Heliocentric. The former treats of celestial motion, as seen from the Earth; and the latter, as seen from the Sun. The one being the apparent motion of the Heavenly Bodies, and the other, their true motion.

As the true motion of the Planets, can be seen only from the Sun, round which they revolve as their centre; I shall suppose the Student to be situated at the centre of that Luminary, where he could see the whole Starry Heavens at one view. The Stars would then appear to him as so many brilliant points of different magnitudes, scattered in all directions in the concave surface of the sphere, which would every where surround him.

By attentive and repeated observations, he would discover, that nearly all the Stars would always remain at the same relative distance from each other; it is from this permanent quality in their position, that they have derived the name of Fixed Stars.

He would also observe a few others, moving in regular order among the Fixed Stars; which he would find to circulate around him, in different periods of time, and with different degrees of velocity. It is for this reason that they are called Wandering Stars, or Planets.

The Planets are seven in number; namely, Mercury, Venus Tellus or the Earth, Mars, Jupiter, Saturn, and Herschel; besides these there are four smaller Planets lately discovered, called Asteroids: viz. Vesta, Ceres, Pallas, and Juno.

Although our Solar Astronomer would not be able to form a correct idea, as to their distance from him; no more than any one could tell the distance of several lights, placed irregularly at different distances from him, in a dark night; yet he might arrange them in the same order as above, by observing the difference in the velocity of their motions; the first mentioned moving fastest, and the last slowest.

Continuing his observations, he would sometimes see a Star of a very singular appearance, approaching him from a great distance, increasing in its apparent magnitude and lustre, till it passed round him, and then to recede in a line not far distant from that in which it approached him, decreasing in brightness, until it would wholly disappear.

Stars of this description are called Comets: they appear with a long luminous stream or tail, when seen sideways from the Earth, but when viewed from the Sun, the tail, being behind the Comet, with respect to the Sun, would not be seen; except its extremity, which, being the broadest part, would appear to surround the head or body of the Comet, in the form of hair.

These Planets and Comets, when spoken of as a whole, form with the Sun, what is denominated the Solar System.

The Earth or Planet on which we live, is the third in order of the Solar System, and is one of those Wandering Stars, which our supposed Solar Astronomer saw revolving around him; it is a vast globular or round body, 25,000 miles in circumference, and is inhabited on all sides by different nations and tribes of people, except at the Poles, where the cold is supposed to be too intense for human beings to exist.

The Starry Sphere is so immensely great, that the Earth, though revolving round the Sun, at a distance of 95 millions of miles, is apparently suspended in the centre of it, so that, to whatever part of the World we may go, we shall there find the Heavens spread over our heads, and bespangled with Stars; which on account of the immensity of their distance, have the same stationary appearance with respect to each other, when seen from the Earth, as they have when viewed from the Sun.

The Stars visible to the naked eye are not so numerous, as at first sight we might imagine them to be, for, supposing a person to be standing on a hill, where he could have an uninterrupted view of the Heavens all around him, he would not see more than a thousand, at the same time, not even on a clear winter's night: a deception arising from the confused manner in which people in general look upon them.

To such persons, the Stars appear to be so numerous, that they think it fruitless to make an attempt to number them; if they were to select any portion of the Heavens, the Constellation of Orion for instance, and with the assistance of one of the accompanying Maps, they would find it, not only possible to count them, but would be surprised to find the part chosen, to contain so few. Again, if they were to take a common spy-glass, and view the same part of the Heavens, they would be astonished at the increased number of Stars, thus brought within their sight; but even these are nothing in comparison with the myriads discovered by the high magnifying powers of the Telescope.

> "Come forth, O Man, yon azure round survey,
> And view those Lamps, which yield eternal day.
> Bring forth thy Glasses; clear thy wond'ring eyes:
> Millions beyond the former millions rise:
> Look farther:—Millions more blaze from remoter skies."

It is not to be imagined that the Stars are all placed in the concave surface of the Celestial Sphere, at equal distances from the Earth, or from the Sun; but, that they are diffused throughout universal space in such a manner, that there may be as great a distance between any two neighbouring Stars, as there is between the Sun and them which are nearest to him. These imaginations have been fully verified by the observations of Astronomers, who have always discovered more Stars, in proportion to the improvements made in their instruments.

The Planets may be known from the Fixed Stars, by their always shining with a steady light, whereas the Fixed Stars are more brilliant, and are continually displaying that appearance which is called their twinkling; this is said to arise conjointly from the smallness of their appearance, and from the minute intervening particles which are constantly floating in the atmosphere, and which, for an instant, deprive us of a sight of them; when the intervening particle is removed, we again see the Star: a quick and perpetual succession of them, will, of course, occasion a continual twinkling.

CLASSIFICATION OF THE FIXED STARS.

The Fixed Stars are so numerous that it would be impossible to apply names to them all, or even to them that are visible to the naked eye, so as to retain them in the memory: they are, therefore, arranged into several Classes and Orders; the former consisting of groups called Constellations, and the latter, of the apparent magnitudes of the several Stars, of which they are composed.

These divisions of the Stars were invented by the Ancients, who formed about 48 Constellations, which they fancifully represented by the figures of their heroes, beasts, birds, fishes, &c.

The antiquity of the Constellations is proved by the writings of the ancient heathen poets, Hesiod and Homer, both of whom mention some of them; and also by the book of Job, chap. 9. ver. 9. and chap. 38. ver. 31. where Arcturus, Orion, and the Pleiades are twice spoken of. The Seven Stars and Orion are also mentioned in the prophecy of Amos, chap. 5. ver. 8.

As the ancient Constellations did not include the whole of the Stars, they that were not comprehended under either of them, were called Informes or Sporades: but as the knowledge of the Stars became more extensive, these Informes were progressively reduced into new Constellations, and certain figures applied to them. The number now generally represented on the British Celestial Globes, is ninety-four, but foreign Astronomers have added several more to that number, and it is probable that others will continue to be invented.

It is not to be understood that such figures can be seen in the Heavens, nor, that any outline of them can be traced in the disposition of the Stars included by their boundaries;—the Constellations were undoubtedly invented for the purpose of referring with ease to any part of the Heavens; and whilst their names answer the intended design, the figures themselves materially help us to retain them in our memories.

The several magnitudes of the Stars, of which there are usually reckoned six, have no reference whatever to their real size; but to their different degrees of brilliancy; the brightest being denominated the first, and those just discernible to the unassisted eye, the sixth magnitude.

The Stars of each Constellation are also distinguished by the letters of the Greek alphabet; the principal Star being denoted by the first letter, the next to it in brightness by the second letter, and so on through the alphabet;—thus the principal Star in Orion is called Alpha Orionis, the next Beta Orionis, &c. If there be more Stars in the Constellation, than letters in the Greek alphabet, then the small Roman letters are used in the same order: the ordinal numbers are also applied to those which exceed the two alphabets.

Besides the above distinctions, many of the principal Stars have particular names applied to them, as Arcturus, in Boötes; Capella, in Auriga; Rigel, in Orion; Sirius, in Canis Major; and Castor, in Gemini.

By this contrivance, it is as easy to find the place of any given Star in the Heavens, as it is to find the situation of a city or town on the Earth. For instance, suppose I wish to find Sirius, and I am informed that it is a Star of the first magnitude in Canis Major; I first look on the map, or globe for the constellation Canis Major, and then within its boundaries for the star required.

We are not, however, to infer from this distinction, that all the Stars included in each denomination are of equal brightness, for Vega is brighter than Capella, and the splendour of Sirius exceeds any other in the Heavens, yet they are all three of the first magnitude; the same remark may be applied to those of the second, third, &c.

The best way to acquire a practical knowledge of the several magnitudes of the Stars, is to compare them with others that are well known, or such as can be easily learned, and which are visible all the year round; thus Capella, in Auriga; and Vega, in Lyra, will serve as a standard for the first magnitude; those in the tail of Ursa Major, viz. Alioth, Mizar, and Benetnasch for the second; the five forming the W in Cassiopeia, for the third; and the three which form a small triangle in the head of Cepheus, for the fourth magnitude.

Besides the preceding classifications of the Starry Heavens, they are also divided into three distinct regions, viz. the Zodiacal, the Northern, and the Southern region.

The Zodiacal, includes those constellations which are situated in and about the Sun's apparent annual path, called the Ecliptic, being twelve in number.

The Northern includes all them that are north of the Zodiac, of which there are usually reckoned thirty-five.

The Southern comprehends about forty-seven, situated on the south of the Zodiac; making a total of ninety-four constellations.

The Zodiac itself includes a space about 8 or 10 degrees on the north and south side of the Ecliptic, and encompasses the Heavens like a belt or girdle. It is divided into twelve equal parts, called Signs, of thirty degrees each, which are represented by the names of the Zodiacal Constellations, and correspond with the twelve months of the year. These Signs serve to mark the apparent progress of the Sun, Moon, and Planets, in their periodical revolutions. Further information on this subject will be found in the description of the third moveable plate.

The following Tables contain lists of all the Constellations on the British Celestial Globes, with the number of Stars in each, according to Flamstead's Catalogue. The last two columns contain the Right Ascension and Declination of the middle of each Constellation by which they may be readily found on the Globe.

ZODIACAL CONSTELLATIONS.

NORTH OF THE EQUINOCTIAL LINE.

Characters of the Signs.	*Latin Names.*	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
♈	Aries.	The Ram.	66	35°	20°N.
♉	Taurus.	The Bull.	141	65	17 N.
♊	Gemini.	The Twins.	85	108	15 N.
♋	Cancer.	The Crab.	83	125	20 N.
♌	Leo.	The Lion.	95	157	15 N.
♍	Virgo.	The Virgin.	110	191	5 N.

SOUTH OF THE EQUINOCTIAL LINE.

Characters of the Signs.	*Latin Names.*	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
♎	Libra.	The Balance.	51	225°	11°s.
♏	Scorpio.	The Scorpion.	44	243	26 s.
♐	Sagittarius.	The Archer.	69	290	35 s.
♑	Capricornus.	The Sea Goat.	51	314	20 s.
♒	Aquarius.	The Water Bearer.	108	335	10 s.
♓	Pisces.	The Fishes.	113	10	10 s.

NORTHERN CONSTELLATIONS.

CONSTELLATIONS WHICH NEVER SET IN THE LATITUDE OF LONDON.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Ursa Minor.	The Little Bear.	24	241°	80°N.
Draco.	The Dragon.	80	270	65 N.
Cepheus.	Cepheus.	35	333	70 N.
Tarandus.	The Rein Deer.	10	34	74 N.
Camelopardalis.	The Camelopard.	58	70	66 N.
Lynx.	The Lynx.	44	110	47 N.
Ursa Major.	The Great Bear.	87	160	60 N.
Cassiopeia.	The Lady in her Chair.	55	12	60 N.
Cor Coroli.	Charles's Heart.	3	191	40 N.

CONSTELLATIONS WHICH PARTIALLY SET IN THE NORTH.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Lyra.	The Harp.	22	280°	38° N.
Cygnus.	The Swan.	81	305	40 N.
Lacerta.	The Lizard.	16	335	45 N.
Andromeda	Andromeda.	66	12	40 N.
Perseus et Caput Madusa	Perseus & Madusa's hd.	59	50	40 N.
Auriga.	The Charioteer.	66	85	43 N.
Boötes.	The Herdsman.	54	217	30 N.
Canes Venatici.	The Grey Hounds.	25	193	42 N.
Hercules et Cerberus.	Hercules and the Three-headed Dog.	113	260	30 N.
Leo Minor.	The Little Lion.	53	150	35 N.

CONSTELLATIONS WHICH WHOLLY RISE AND SET.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Serpentarius vel Ophiuchus.	The Serpent-bearer.	74	255°	2° N.
Serpens.	The Serpent.	64	252	10 S.
Taurus Poniatowski.	Poniatowski's Bull.	7	274	6 N.
Scutum Sobieski.	Sobieski's Shield.	8	276	10 S.
Aquila et Antinoüs.	The Eagle and Indian Youth.	71	290	5 N.
Sagitta.	The Arrow.	18	295	18 N.
Vulpecula et Anser.	The Fox and the Goose.	37	304	25 N.
Delphinus.	The Dolphin.	18	310	13 N.
Pegasus.	The Flying Horse.	89	340	17 N.
Equuleus vel Equi Sectio.	The Colt, or Horse's Head.	10	315	5 N.
Triangulum.	The Triangle.	16	29	22 N.
Musca Borealis.	The Northern Fly.	6	38	28 N.
Corona Borealis.	The Northern Crown.	43	185	25 N.
Mons Mænalus.	Mount Mænalus.	11	224	8 N.

SOUTHERN CONSTELLATIONS.

CONSTELLATIONS WHICH WHOLLY RISE AND SET.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Orion.	Orion.	78	81°	0°
Lepus.	The Hare.	19	81	18 s.
Monoceros.	The Unicorn.	31	108	2 s.
Canis Minor.	The Little Dog.	14	111	6 N.
Canis Major.	The Great Dog.	31	99	22 s.
Hydra.	The Water-Serpent.	60	138	8 s.
Sextans.	The Sextant.	41	150	0
Pyxis Nautica.	The Mariner's Compass.	4	132	31 s.
Antlia Pneumatica.	The Air Pump.	3	153	32 s.
Crater.	The Cup.	31	170	15 s.
Corvus.	The Crow.	9	185	16 s.
Pisces Australis.	The Southern Fish.	24	333	31 s.
Cetus.	The Whale.	97	25	11 s.
Brandenburgium Sceptrum.	The Sceptre of Brandenburg.	3	65	15 s.

CONSTELLATIONS WHICH PARTIALLY RISE IN THE SOUTH.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Apparatus Sculptoris.	The Sculptor's Apparatus.	12	2°	35° s.
Fornax Chemica.	The Chemical Furnace.	14	40	30 s.
Eridanus.	The River Po.	84	55	23 s.
Cela Sculptoria.	The Graver's Tools.	16	71	37 s.
Columba Noachi.	Noah's Dove.	10	84	35 s.
Argo Navis.	The Ship Argo.	64	120	45 s.
Centaurus.	The Centaur.	35	195	50 s.
Lupus.	The Wolf.	24	230	42 s.
Microscopium.	The Microscope.	10	277	50 s.

CONSTELLATIONS WHICH NEVER RISE IN THE LATITUDE OF LONDON; THEREFORE ARE NOT INCLUDED IN THE MAPS.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Pavo.	The Peacock.	12	315°	55° s.
Indus.	The Indian Youth.	14	300	67 s.
Octans Hadleianus.	Hadley's Quadrant.	43	280	82 s.
Grus.	The Crane.	13	235	45 s.
Touchan.	The American Goose.	9	355	63 s.
Phœnix.	The Phœnix.	13	15	46 s.
Horologium.	The Time Piece.	12	45	55 s.
Hydrus.	The Water Snake.	10	37	70 s.
Reticulus Rhomboidalis.	The Rhomboidal Net.	10	57	82 s.
Equuleus Pictoris.	The Painter's Easel.	8	78	50 s.
Dorado.	The Sword Fish.	7	75	60 s.
Mons Mensæ.	The Table Mountain.	30	70	74 s.
Pisces Volans.	The Flying Fish.	8	114	68 s.
Robur Caroli.	Charles's Oak.	12	159	52 s.
Crux.	The Cross.	6	183	59 s.
Musca Australis.	The Southern Fly.	4	186	70 s.
Chamælion.	The Camelion.	10	170	80 s.
Circinus.	The Compasses.	4	223	62 s.
Triangulum Australis.	The Southern Triangle.	5	235	65 s.
Norma vel Quadra Euclidis.	Euclid's Square.	12	242	44 s.
Ara.	The Altar.	9	256	52 s.
Apus vel Avis Indica.	The Bird of Paradise.	11	240	75 s.
Corona Australis,	The Southern Crown.	12	280	40 s.
Telescopium.	The Telescope.	9	278	50 s.

MODERN CONSTELLATIONS WHICH ARE NOT UNIVERSALLY ADOPTED.

NORTHERN.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Telescopium Herschelii.	Herschel's Telescope.	17	102°	41° N.
Gloria Frederici.	Frederick's Glory.	38	350	45 N.
Quadrans Muralis.	The Mural Quadrant.	9	222	53 N.
Custos Messium vel L' Messier.	The Guardian of the Harvest.	10	34	67 N.

SOUTHERN.

Latin Names.	*English Names.*	*No. of Stars.*	*R. A.*	*Dec.*
Avis Soliairia vel Noctua.	The Owl.	20	208°	23° s.
Ballon Aerostatique.	The Air Balloon.	9	317	30 s.
Felis.	The Cat.	28	145	20 s.
L'Atelier Typographique	The Printing Press.	16	117	15 s.
Psalterium Georgianum.	George's Harp.	11	55	5 s.

As the Greek Alphabet is used to denote the several Stars on the Globe, &c. I have introduced it here for the convenience of those who may be unacquainted with it; reminding them at the same time, that the Small Letters only are made use of for that purpose. The Capitals are inserted for the sake of uniformity; but the powers or sounds of the letters are omitted, as having no connexion with the subject before us.

Capitals.	*Small.*	*Names.*	*Capitals.*	*Small.*	*Names.*
Α	α	Alpha.	Ν	ν	Nu.
Β	β, ϐ	Bēta.	Ξ	ξ	Xi.
Γ	γ	Gamma.	Ο	ο	Omīcron.
Δ	δ	Delta.	Π	ϖ, π	Pi.
Ε	ε	Epsīlon.	Ρ	ρ, ϱ	Rho.
Ζ	ζ, ζ	Zēta.	Σ	σ, ς	Sigma.
Η	η	Eta.	Τ	τ	Tau.
Θ	ϑ, θ	Thēta.	Υ	υ	Upsīlon.
Ι	ι	Iôta.	Φ	φ	Phi.
Κ	ϰ	Kappa.	Χ	χ	Chi.
Λ	λ	Lambda.	Ψ	ψ	Psi.
Μ	μ	Mu.	Ω	ω	Omĕga.

DESCRIPTION

AND

ASSOCIATION OF THE CONSTELLATIONS.

THE English names and order of the Zodiacal Signs and Constellations, may be readily learned, and as easily retained, by committing to memory the following poetical lines by Dr. Watts, viz.

The RAM, the BULL, the heavenly TWINS,
And next the CRAB, the LION shines,
The VIRGIN, and the SCALES;
The SCORPION, ARCHER, and SEA-GOAT,
The MAN who holds the WATER-POT,
And FISH with glittering tails.

And by associating the Northern and Southern Constellations together, according to their mythological relations, or local connexions, not only their names, but their situations also may be remembered.

ZODIACAL CONSTELLATIONS.

Spring Signs.

ARIES, TAURUS, AND GEMINI.

ARIES, according to the Grecian fables, is the RAM, with a Golden Fleece, on which Phryxus and his sister Helle fled from Ino, their step-mother. Crossing a narrow part of the sea, on this animal, Helle fell off and was drowned: hence this part has ever after been called the Hellespont; Phryxus was carried safe over, and arrived at Colchis, where he married Chalciope, daughter of Ætes, king of that country; who some time after killed his son-in-law, in order to obtain the Golden Fleece. To revenge his death and to regain the Fleece was the principal object of the Argonautic expedition. The Ram had been previously sacrificed to Jupiter, who made it a Constellation.

The character (♈) is a representation of the horns of the Ram.

This Constellation contains 66 Stars, viz. Arietis of the second, one of the third, and two of the fourth magnitude, the rest being smaller. Aries rises in the E. N. E. and continues visible from the beginning of September till March.

This is the first Sign of the Zodiac; the beginning of the spring, and of the Astronomical year. The sun enters it about the 20th of March, when being in the Spring Equinox, he distributes equal day and night to all parts of the Earth, except at the Poles; for it is the opening of the day at the North, and the close of the day at the South Pole.

Taurus, *the Bull.* The mythologists inform us, that this was the Bull, whose shape Jupiter assumed when he carried off Europa, across the sea into Crete, where he disclosed his divinity to her, and placed the Bull among the Stars. The Sidonians stamped medals in honour of her, with the picture of a woman riding over the sea on a Bull.

It contains 141 Stars, viz. Aldebaran of the first, El Nath of the second, four of the third, nine of the fourth, and the others of a less magnitude.

The character of this sign (♉) represents the face and horns of the Bull.

Taurus contains two small Constellations, viz. the *Pleiades,* and *Hyades.*

The Pleiades, or, as they are commonly called, the *Seven Stars,* are the seven daughters of Atlas and Pleione, viz. Maia, Electra, Taygeta, Asterope, Merope, Halcyone, and Celœne. They were translated to the Heavens by Jupiter, in compliance with their earnest entreaties, to avoid the pursuit of Orion.

This Constellation contains 78 Stars, only 6 of which are visible to the naked eye. It is situated on the right shoulder of Taurus, near the tropic of Cancer; it rises in the N. E. and may be seen in the evenings from the beginning of October till April.

The Hyades were also the daughters of Atlas by Æthra, viz. Ambrosia, Coronis, Eudora, Pasithoë, Plexaris, Pytho, and Tyche, the whole of whom fell into continual fits of weeping for the loss of their brother Hyas, who was devoured by a lion, till Jupiter out of compassion, changed them into this Constellation. The principal Star of this group is Aldebaran in the southern eye of the Bull, it is of a dusky red appearance, similar to the planet Mars.

Taurus is the second of the Zodiacal, and of the Spring Signs, into which the Sun enters about the 20th of April, when the length of the days is increasing in the Northern, and decreasing in the Southern Hemisphere.

GEMINI, *the Twins.* The mythologists inform us, that these were Castor and Pollux, sons of Leda, by Jupiter, who to gain the love of Leda, assumed the likeness of a Swan.* The Twins accompanied Jason in his expedition to Colchis for the Golden Fleece. In the course of the voyage they were overtaken by a violent storm; and while Orpheus, one of the Argonauts, was making vows to the gods for the safety of the Ship, two meteors appeared playing about the heads of Castor and Pollux, and a dead calm immediately followed. This event gained them divine honours, and ever after when such meteors were seen, the general belief was that they were sent by their command. If two appeared they were considered to be favourable, and were termed Castor and Pollux; but if only one was seen, it was deemed to be the sign of an approaching storm, and therefore called Helena. These notions are entertained by mariners to the present day; the meteors generally appear about the rigging of the ship, particularly where there is iron; I recollect having seen one on the spindle of the vane, and I affirm, without being superstitious, that a most tremendous storm ensued.

The character (♊) is composed of two parallel lines joined together at the top and bottom, in imitation of the Twins clasping each other.

This Constellation contains 85 Stars, viz. Castor of the first, Pollux and Gamma of the second; three of the third; and five of the fourth magnitude, the rest being very small. It rises in the N.E. and may be seen in the evenings from November to the middle of June.

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* See the Constellation Cygnus.

It is the third of the Zodiacal, and last of the Spring Signs; the Sun enters it about the 21st of May, when the length of the days is still increasing in the Northern Hemisphere, and decreasing in the Southern.

It is conjectured by some, that the figures of the Zodiacal Constellations are Egyptian Hieroglyphics, and that they are descriptive of the Seasons, or of some remarkable occurrence in each month of the year. Thus, while the Sun was passing through the three Spring Signs, the animals which they held in the highest estimation, were produced, viz. Sheep, Black-cattle, and Goats; the latter being the most prolific, were originally represented by two kids; but now by Gemini or the Twin-brothers, Castor and Pollux.

Summer Signs.

CANCER, LEO, AND VIRGO.

CANCER, *the Crab.* The Greeks say, that when Hercules was contending with the Lernæan Hydra, Juno sent a crab to annoy him, which having fixed upon his foot, the hero instantly shook it off and crushed it to atoms. The Goddess, however, as a reward for its services, placed it among the Constellations. But,

According to the Egyptian Hieroglyphical representation, the crab is supposed to resemble the motion of the Sun when in this sign, which passes sideways along the Tropic of Cancer, without crossing it: for, supposing a crab to be confined to a certain space, it would crawl to the extremity on one side, and then retrace its steps to the other, somewhat similar to the motion of the Sun at this season, which after having attained his greatest elevation towards the North, begins to descend towards his Southern limits, the Tropic of Capricorn.

The character (♋) pointing both ways, is also emblematical of the change in the Sun's declination.

This Constellation consists of 83 Stars, none of which are larger than the fourth magnitude. It rises in the E. N. E. and is visible in the evenings, from December till June.

This is the fourth of the Zodiacal, and the first of the Summer Signs. The Sun enters it about the 21st of June, when he arrives at the Summer Solstice, and produces the longest day to the Northern, and the shortest day to the Southern Hemisphere; the length of the day to the one, being equal to the length of the night to the other, in the same degree of latitude. It is the middle of the artificial day at the North Pole, and of the night at the South Pole.

Leo, *the Lion.* The Greeks fabled that this was the Lion, which, by Juno's enchantment, fell from the circle of the Moon, and infested the Nemæan woods, where he committed dreadful ravages among the herds; till killed by Hercules, who ever after wore his skin as a garment. But it is more probable that the Egyptians placed this hieroglyphic here, either to represent the great heat of the Sun in his passage through this sign; or, because at this season of the year, the lions often left the sandy deserts, to quench their thirst at the banks of the Nile.

The character (♌) represents the tail of the lion in a state of agitation.

This Asterism contains 95 Stars, viz. Regulus, or Cor Leonis, in the heart, and Denebola in the tail, of the first; two of the second; five of the third, and the rest of an inferior magnitude. It rises E.N.E. and may be seen in the evenings from the beginning of January till the middle of June.

Leo is the fifth of the Zodiacal, and the second of the Summer Signs. The Sun enters it about the 23d of July, when he is fast declining towards the South; hence the days are becoming shorter in the North, and longer in the South, Temperate Zone.

Virgo, *the Virgin.* The origin of this Constellation, as related by the fabulists, is this, that Astræa, daughter of Jupiter and Themis, the goddess of justice, who distributed to every one his due proportion, came down to reside on the Earth during the Golden Age; but, when men gave themselves up to vice, she returned to Heaven, and was made a Constellation of the Zodiac.

The figure is that of a Virgin, with wings on her shoulders; holding a palm branch in her right hand, and a few ears of corn in her left, denoting the time of harvest.

This is the present character of the sign (♍), but three ears of corn was the original one.

This Constellation consists of 110 Stars, viz. Spica Virginis of the first; Vindemiatrix and five others of the third; eleven of the fourth, and the remainder of a less magnitude. Spica Virginis rises in the E.S.E. and may be seen every clear evening from the beginning of April till the end of June.

This is the last of the Summer Signs, and the sixth in order of the Zodiac. The Sun enters it about the 23d of August, decreasing in his declination, and passing vertically over New Spain, the Coast of Guinea, and the Philippine Islands.

Autumnal Signs.

LIBRA, SCORPIO, AND SAGITTARIUS.

LIBRA, *the Balance.* The Grecian fabulists do not give any plausible account of the origin of this Sign, therefore it inclines us to look to the Egyptians as the inventors; who most probably placed it in this part of the Zodiac, as an emblem of the equality of day and night.

The character (♎) is intended to represent the beam of the Scales.

This Constellation includes about 51 Stars, viz. Zuben el Gemubi in the north scale, and Zuben el Chamah in the south scale, both of the second; Zuben ha Krabi, and Zuben el Gubi, of the third; and 12 of the fourth magnitude. The principal Stars rise in the E.S.E. and continue visible every evening from the beginning of May till September.

Libra is the seventh of the Zodiacal, and the first of the Autumnal Signs. The Sun enters it about the 23d of September; the time of the Autumnal Equinox; when equal day and night is again experienced by all the inhabitants of the earth, between the arctic and the antarctic regions. At the North Pole the Sun is setting, to rise no more for six months; and at the South Pole it is rising, to set no more for the same length of time.

Scorpio, *the Scorpion.* It is said that Orion,* boasting of his superior skill as a hunter, so offended the Goddess Diana, that she sent a Scorpion, which after mortally wounding him with its sting, was transformed into this Constellation.

The Greeks also relate a story, that Diana was so fond of Orion, that she intended to marry him; but Apollo, her brother, disapproving of the union, made use of a stratagem by which she unintentionally shot him with one of her arrows.

But the Egyptians undoubtedly placed this poisonous reptile in this sign as an emblematical representation of the dreadful maladies which usually attack mankind at this season of the year.

The character (♏) is in the form of the letter m with the point of the last stroke barbed like a sting or dart.

The boundaries of this Constellation enclose 44 Stars, viz. Antares of the first; one of the second; ten of the third, and the rest of a less magnitude. Antares, its principal Star, rises in the S.E. and may be seen every evening, a few degrees above the horizon, from the beginning of June till the middle of August. The tail which contains eight Stars of the third magnitude does not rise at London.

This is the second of the Autumnal, and the eighth of the Zodiacal Signs. The Sun enters it about the 23d of October, and is vertical at noon to Lima and St. Salvador, in South America; to the northern extremity of Madagascar and that of New Holland, where, of course, it is the height of Summer.

Sagittarius, *the Archer.* The figure of this sign is a Centaur, or an animal half a man and half a horse, in the act of shooting an arrow from his bow; who, according to the Greeks, was Chiron the son of Saturn and Phillyra. He was considered the most accomplished master of the fine arts; and had the honour of being the preceptor of Achilles; he also taught Æsculapius physic, and Hercules astronomy; and was, after his death, changed into this Constellation.

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* See the Constellation of Orion.

It is otherwise supposed, that the Egyptians placed him in this sign as an emblem of the hunting season which commences at this time of the year.

The character (♐) is an arrow, which also has a reference to hunting.

This Constellation contain 69 Stars, only five of which are of the third magnitude, situated between his left shoulder and the bow. They rise in the S. S. E.; ascend but a few degrees above the horizon, and continue visible, about three hours and half every evening, from the beginning of July till the end of August.

Sagittarius is the ninth of the Zodiacal, and the last of the Autumnal signs. The Sun enters it about the 22d of November, when his meridian altitude is about 17 degrees, consequently the days are then getting very short.

Winter Signs.

CAPRICORNUS, AQUARIUS, AND PISCES.

CAPRICORNUS, *the Sea-Goat.* The Greeks pretend that this was the Goat, named Amalthea, which suckled Jupiter in his infancy, who, when he grew up, had it placed among the Stars, as a reward for its kindness; he also, by the advice of Themis, covered his shield with its skin, in order to strike a terror into his enemies. Its horn was called, the Horn of Plenty, because he who possessed it, was supposed to be able to obtain all he desired.

The figure is that of a monster, having the head of a goat, and the tail of a fish; and sometimes it is that of a common goat, which delights in climbing the sides of mountains and precipices. It is therefore very probable, that the Egyptians appropriated it to this part of the Zodiac, as an emblem of the Sun's motion, it having now descended to its utmost southern limits, the Tropic of Capricorn, where it begins to re-ascend, mounting higher every day, till it reaches the Tropic of Cancer, its highest point in the heavens.

The character (♑) is supposed to resemble the twisted tail of the goat which characterises this sign.

This Asterism consists of 51 Stars, viz. two in the head, and Deneb Algedi in the tail, of the third magnitude; two of the fourth, and the rest smaller. The principal Star in the head rises in the E. S. E. and is visible only from midsummer till the middle of November.

This is the first of the Winter, and the tenth of the Zodiacal Signs. The Sun enters it about the 22d of December, when the Winter Solstice takes place. It is then mid-day at the South Pole, and midnight at the North Pole.

AQUARIUS, *the Water-bearer*. Xenophon informs us, that Ganymedes, son of Tros, King of Troy, was such an accomplished youth, and his external beauty corresponding so much with his inward virtues, that Jupiter thought him a fit companion for the gods; who accordingly sent his faithful minister, the Eagle,* to convey him from mount Ida, to the celestial regions, where, being placed among the Stars, Jupiter turned him into the Sign Aquarius, to attend on him at his banquets with flowing cups of nectar.

The figure is that of a Man pouring water from a vessel, thereby denoting the wet and unpleasant season of the year, in which the Sun passes through this sign.

The character (♒) is an imitation of the undulatory motion of the waters.

This Constellation contains 108 Stars, viz. four of the third, six of the fourth, and the rest of an inferior magnitude. The principal Star, in the right shoulder, rises E. by S. about the beginning of August, when the Nile overflows, and public rejoicings are made at Cairo. It continues visible till January.

Aquarius is the eleventh of the Zodiacal, and the second of the Winter Signs. The Sun enters it about the 20th of January, when the length of the day is increasing in the Northern Hemisphere, and decreasing in the Southern.

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* See the Constellation of Aquila.

Pisces, *the Fishes.* The Mythologists do not give any plausible account of the origin of this Sign: some say that the Egyptians, who never ate fish, considering them as an abomination, placed them here because they supposed that this Sign had some malignant influence over their affairs.

The figure is that of two fishes tied together by the tails with a long cord; and the character (♓) is supposed to resemble two fishes tied back to back; denoting thereby that the rivers are now open for the commencement of the fishing season.

The Constellation contains 113 Stars, viz. one near the neck of Cetus, of the third magnitude, five of the fourth, and the rest very small. The Northern fish is situated near Mirach in the girdle of Andromeda, and the Southern one below Markab in Pegasus. The former rises in the N. E. by N. and the latter due East. Both of them become visible, in the Eastern part of the Heavens, in the evenings, about the middle of August. The Southern fish disappears in the West about the middle of January; but the Northern one continues visible till the middle of March.

This is the last of the Winter and of the Zodiacal Signs. The Sun enters it about the 19th of February, when it is again vertical at noon to the same places as it was when it entered Scorpio. The day is fast declining at the South Pole, and beginning to dawn at the North Pole.

NORTHERN CONSTELLATIONS.

CEPHEUS, CASSIOPEIA, ANDROMEDA, PERSEUS, PEGASUS, EQUULEUS, TRIANGULUM, AND MUSCA BOREALIS.

Cepheus, was a king of Æthiopia, and father of Andromeda; he is represented on the Globe in the costume of an oriental monarch, in a sitting posture, with his sceptre in his right hand.

This Asterism consists of 35 Stars. There are three of the third, and five of the fourth magnitude, the rest being smaller. It is within the circle of perpetual apparition, consequently it does not set to the inhabitants of London.

Cassiopeia, *the Lady in her Chair*, is the wife of Cepheus, and the mother of Andromeda. She is represented sitting in a chair, and drawing her mantle over her right shoulder. She boasted of her beauty being greater than that of the Nereides or Sea Nymphs, which so offended Neptune, that he sent a sea monster* to ravage the country of Æthiopia:—Nothing could appease his wrath, but the sacrifice of Andromeda, her daughter, which would have been accomplished, had it not been prevented by the timely interference of Perseus.

This Constellation contains 55 Stars, five of which are of the third magnitude, remarkable for forming an outline of the letter W, which may be seen every night in the year.

Andromeda, the daughter of Cepheus and Cassiopeia. She is represented as being chained by her wrists to a rock, to be devoured by the sea monster, from which she was delivered by Perseus, who afterwards made her his wife. The places of 66 Stars have been marked in this Constellation, viz. Alpheratz, Mirach, and Almaach of the second magnitude, two of the third, and twelve of the fourth. Alpheratz in her head rises in the N. E. and continues visible in the evenings from July till April.

Perseus, was the son of Jupiter and Danaë; he slew Madusa, one of the Gorgons, and cut off her head, with which he performed many wonderful exploits. On returning from the slaughter of the Gorgons, he met with the sea monster, and turned him into a rock by shewing him the head of Madusa, and thus rescued Andromeda from her perilous situation. He is represented on the Globe, with wings at his ancles, a sword in his right, and Madusa's head in his left hand.

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* See the Constellation Cetus.

This constellation, including Caput Madusa, consists of 69 Stars, viz. Algenib and Algol, of the second magnitude, four of the third, nine of the fourth, and the rest smaller; the greater part of which are visible all the year.

Pegasus, *the Flying Horse,* is said by the Greeks, to have sprung from the blood of Madusa, when Perseus cut off her head.

It contains 89 Stars; Markab, Scheat, and Algenib of the second, three of the third, ten of the fourth, and others of a less magnitude. Markab the chief Star is situated in his body, it rises in the E. N. E. and is visible in the evenings from the middle of June till February.

Equuleus, *the Colt,* is by some supposed to be the brother of Pegasus, and by others, to be the horse which Mercury gave to Castor.

It contains only 10 Stars, viz. four of the fourth magnitude, and six smaller. It rises a little north of the east, and continues visible every evening from the beginning of July till the end of the year.

Triangulum, *the Triangle,* is supposed to have derived its name from the Delta, a fertile tract of land in Lower Egypt, lying between the mouths of the Nile, resembling the Greek letter* of the same name. A lesser triangle has been added to the ancient one by Hevelius. The whole Constellation contains 16 Stars, three of which are of the fourth magnitude, and three of the fifth; the former being in the greater, and the latter in the lesser triangle. It rises in the N. E. and may be seen in the evenings from July till April.

Musca Borealis, *the Northern Fly.* A new Constellation, consisting of six Stars, one of them being of the third, and two of the fifth magnitude.

It rises in the N.E. and is visible in the evenings with Triangulum.

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* See the Greek Alphabet.

In this association we find Cepheus in a line with the pointers in Ursa Major, but on the opposite side of the Pole Star; with Cassiopeia on his right hand. Andromeda is south of Cassiopeia, with Pegasus and Equuleus near her head, and Perseus, her preserver, at her feet. On the South of her, are Triangulum and Musca Borealis.

AURIGA, LEO MINOR, LYNX, CAMELOPARDALIS, AND TARANDUS.

Auriga, *the Charioteer*, is depicted on the Globe, as a Man in a kneeling attitude, with a Goat and her Kids in his left hand, and a bridle in his right. He is generally supposed to be Myrtilus, son of Mercury and Clymene, and charioteer to Oënomeus king of Pisa.—Oënomeus had promised his daughter Hippodamia in marriage to any person who could outdrive him in a chariot, on condition that the defeated should suffer death; thirteen had made the attempt, and lost their lives; when Pelops, having bribed Myrtilus, gained the prize, and slew Myrtilus afterwards, for claiming a share in the reward: but being a son of Mercury he was made a Constellation.

This Asterism contains 66 Stars, viz. Capella, a beautiful Star of the first magnitude, El Nath of the second; nine of the fourth, and the rest smaller. Capella never sets to the inhabitants of Great Britain.

Leo Minor, *the Little Lion*, situated between Leo Major and Ursa Major, consisting of 53 Stars, viz. one of the third magnitude; five of the fourth, and the others less. Its principal Star rises in the N.E. by N. and is visible in the evenings from Christmas till August.

Lynx, *the Lynx*, is a spotted animal, remarkable for its swiftness, and sharpness of sight. It consists of 44 Stars, only one of which is larger than the fifth magnitude, and which never sets in the latitude of London.

Camelopardalis, *the Camelopard*, is an animal of Ethiopia, remarkably tame, very tall, and spotted like the Leopard.

It contains 58 Stars, only six of which are so large as the fourth magnitude. It is always visible at London.

This and the preceding two Constellations, were made out of the ancient Sporades, by Hevelius, a celebrated astronomer, born at Dantzic in Prussia.

Tarandus, *the Rein Deer,* is a small Constellation, formed by Le Monnier, of about ten small Stars, which formerly belonged to Cepheus and Cassiopeia, they are always visible.

Auriga is situated on the East of Perseus, having the Lynx between him and Ursa Major; with Camelopardalis and Tarandus on the North.

URSA MAJOR, AND URSA MINOR, BOÖTES, MONS MÆNALUS, CANES VENATICI, COR COROLI, AND COMA BERENICES.

Ursa Major, *the Great Bear,* is said to have been Calisto, the daughter of Lycaon, king of Arcadia, the former being turned into a bear by Juno, was nearly killed by her son Arcas in hunting: Jupiter, therefore, to protect her from future harm, translated her to the Heavens. This remarkable Constellation is generally known by the name of Charles' Wain, or the Plough and Horses.

It contains 87 Stars, viz. Dubhe of the first magnitude, Merak, Phach'd, Alioth, and Benetnasch of the second, Megrez and three more of the third; thirteen of the fourth, and the rest of smaller magnitude. Dubhe and Merak are called the Pointers, because they point to the North Pole Star. It is visible all the year.

Ursa Minor, *the Little Bear,* is supposed to be Arcas, son of Jupiter and Calisto, the former of whom having been killed by his grandfather Lycaon, Jupiter turned him into this Constellation.

It consists of 24 Stars, one of which is of the second magnitude, in the extremity of the tail, called Alruccabah, or the Pole Star; three of the third, and three of the fourth. The principal Stars of this Constellation form a figure similar to the seven in Ursa Major; but in a reversed order.

Boötes, *the Herdsman.* The origin of this Constellation appears to be wrapped in obscurity, or to have been lost in a variety of opinions. Some suppose him to have been Lycaon, the father of Calisto, which opinion being the most favourable to my plan of association, is the only reason I have adopted it in preference to others: He is represented on the Globe in the character of an Elderly Man in a walking attitude, with a club in his left hand, holding Canes Venatici in a cord with his right. The boundaries of this Constellation inclose 54 Stars, viz. Arcturus of the first, six of the third, and twelve of the fourth magnitude. The beautiful Star Arcturus rises in the E.N.E. and is visible every evening from the beginning of March till the end of August.

Mons Mænalus, *the Mountain Mœnalus,* in Arcadia, sacred to Pan, the son of Mercury, and the god of Shepherds. The Mountain derived its name from Mænalus, son of Lycaon, king of Arcadia.

It forms no separate Constellation, but is included in that of Virgo and Serpens.

Canes Venatici, *the Greyhounds,* Asterion and Chara; a new Constellation, formed by Hevelius, and contains 25 Stars. Cor Coroli is its chief Star, of the second magnitude; it just grazes the horizon when on the meridian below the Pole, and may be seen from the 1st of January till October.

Cor Coroli, *Charles's Heart,* is a small Constellation on the neck of Chara, and is included in Canes Venatici. It is represented as a heart surmounted by a crown, and was formed by Sir Charles Scarborough, physician to King Charles II. in honour of his late sovereign Charles I. It consists of only three Stars, the principal of which is Cor Coroli above mentioned.

Coma Berenices, *Berenice's Hair.* Berenice, the wife of Ptolemy Euergetes, king of Egypt, made a vow to dedicate her hair to Venus, (who had immortalized her), if her Husband returned in safety from an expedition on which he was gone into Syria; Euergetes having returned victorious, she consecrated her Hair, and sent it to the Temple of the Goddess; who prevailed on Jupiter, to place it in the Heavens in the form of this Constellation.

Her father Ptolemy Philadelphus, a king of Egypt, founded the celebrated Alexandrian Library, consisting of one hundred thousand volumes. This Asterism contains 43 Stars, eleven of which are of the fourth magnitude. It rises in the N.E. part of the horizon, and may be seen from the beginning of March till August.

Referring to the Globe, we find Boötes with his two Greyhounds, hunting or driving the Great Bear round the Pole, whilst the Little Bear, appears to be fixed by the tail to the Pole, and keeping a watchful eye on Boötes to see the result of the chase. Coma Berenices is south of Canes Venatici, and Mons Mænalus near the feet of Boötes.

HERCULES, CERBERUS, DRACO, SAGITTA, AND CORONA BOREALIS.

Hercules was the son of Jupiter and Alcmene, the former of whom, by the hatred and subtlety of Juno, was subjected to the will of Eurystheus, by whom he was obliged to perform his celebrated twelve labours. He is represented on the Globe in a kneeling posture, with a club in his right hand; Cerberus and the golden apples in his left; and the skin of the Nemæan Lion,* which he slew, over his shoulders.

The places of 113 Stars have been found in this Constellation, six of which are of the third magnitude, and nineteen of the fourth. Ras Algethi in his head is the chief Star; it rises in the E. N. E. and is visible every evening from the beginning of April till November.

Cerberus, *the Three Headed Dog*, belonging to Pluto, by whom he was stationed at the gates of the infernal regions; where, it is said, he fawned upon all those who entered, but devoured all them that attempted to escape.

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* See the Constellation Leo.

The dragging of this monster from the infernal regions, and the bringing of him to Eurystheus, king of Argos, was the last and most dangerous achievement of Hercules. The figure was invented by Hevelius, and is included in the Constellation Hercules, who holds it in his left hand.

Draco, *the Dragon*, according to the fables of the Greeks, was set as a watch over the Golden Apples in the garden of the Hesperides. It was slain by Hercules, that he might obtain some of the fruit to carry to Eurystheus. Juno, having presented the apples to Jupiter on the day of their marriage, took the creature with her to Heaven; and, in consideration of its faithful service, made it a Constellation.

It contains 80 Stars, viz. four of the second magnitude, seven of the third, eleven of the fourth, and the rest smaller. No part of Draco sets to the British Isles.

Sagitta, *the Arrow*, with which Hercules killed the Eagle, that was daily gnawing the liver of Prometheus, who was chained to a rock on Mount Caucasus, by Jupiter, for animating a man with fire, which he had formed of clay.

It is a small Constellation, situated between Vulpecula et Anser and Aquila, consisting of 18 Stars, none of which exceed the fourth magnitude. It rises in the E.N.E. and appears in the evenings from May till December.

Corona Borealis, *the Northern Crown*, is supposed to be that, which Bacchus gave to his priestess Ariadne, daughter of Minos king of Crete, which, after her death, was made a Constellation.

This is a beautiful little Asterism, containing 21 Stars; Gemmi, its principal Star, is of the second magnitude, which with five others of the fourth magnitude, form the circular part of the crown.

It rises in the N. E. and is visible from the 1st of March till November.

Hercules is delineated on the Globe with his feet towards the North Pole, having his left foot on the head of Draco; with Corona Borealis on his right hand, Lyra on his left, and Sagitta at a little distance from him, as if shot from his bow.

SERPENTARIUS, SERPENS, TAURUS PONIATOWSKI, AND SCUTUM SOBIESKI.

Serpentarius vel Ophiuchus, *the Serpent Bearer*, is supposed to be Æsculapius, son of Apollo and Coronis, and God of Physic. He was killed by Jupiter with a thunderbolt, in consequence of his skill in having restored the life of Hypolytus a giant, who had been slain in a war with Jupiter. By whom he was translated to the Heavens, the Mythologists do not inform us.

The figure is that of a Man, with a long beard, holding a Serpent in his hands, which appears to have been an ancient symbol of medicine.

It contains 74 Stars, viz. Ras Alhagus, situate in the head, and about five degrees east of Ras Algethi, in the head of Hercules, of the second magnitude; six of the third, and nine of the fourth. It crosses the Equinoctial, consequently rises due east, and is visible in the evenings from April to October.

Serpens, *the Serpent*, is the same which Ophiuchus grasps in his hands.

It contains 64 Stars, viz. one of the second magnitude; eight of the third; seven of the fourth, and the remainder less. It rises and sets with Ophiuchus.

Taurus Poniatowski, *Poniatowski's Bull*, is a new Constellation, made in honour of Count Poniatowski, a Polish Officer of extraordinary merit. It consists of 7 Stars, four of which are of the fourth magnitude, and situate in his head; they rise due east, and are visible every evening from May to November.

Scutum Sobieski, *Sobieski's Shield*, was formed by Hevelius, in honour of John Sobieski, king of Poland.

It contains 8 Stars, of which only two are so large as the fourth magnitude. It rises in the E.S.E. and can be seen every clear evening from the beginning of June till the middle of October.

Serpentarius crosses the Equinoctial, south of Hercules, having Taurus Poniatowski and Scutum Sobieski on the east.

CYGNUS, LYRA, AND LACERTA.

Cygnus, *the Swan*, this Constellation derived its name, according to the Greeks, from Leda the daughter of Thestius, and wife of Tyndarus king of Lacedæmon. She was deceived by Jupiter in the form of a swan, on the banks of the river Eurotas, by whom she had Castor, Pollux,* and Helena; the latter of whom was the most beautiful woman in the world. She ran away with Paris, and thus occasioned the Trojan War. The Swan, the form of which Jupiter had assumed, was by him translated to the Heavens.

It includes about 81 Stars, viz. Deneb, its chief Star, of the second magnitude, six of the third, and eleven of the fourth. Deneb never sets, and Albiero in its bill, rises about N. E. The whole Constellation may be seen every evening from the beginning of May till the end of the year.

Lyra, *the Harp*, is said, by the Mythologists, to be that which Apollo gave to his son Orpheus, who was a celebrated musician. The Harp having seven strings, represents the harmony of the seven Planets, and it was metamorphosed into this Constellation by the Muses.

It contains 22 Stars, viz. Vega of the first magnitude, two of the third, and the rest very small. Vega just touches the horizon, when on the Meridian below the Pole, and is visible almost every evening in the year; excepting February, when it is too near the northern horizon to be seen.

* See the Constellation Gemini.

Lacerta, *the Lizard,* is a small Constellation, made by Hevelius, containing 16 Stars, only three of which are so large as the fourth magnitude, the greater part of it is visible all the year.

Cygnus occupies a large space in the Via Lactea or Milky Way, south of Cepheus and Draco, having Lyra on the west, and Lacerta on the east, when on the Meridian.

AQUILA ET ANTINOUS, DELPHINUS, AND VULPECULA ET ANSER.

Aquila, *the Eagle,* is supposed by some to have been Merops, a king of the island of Cos, in the Archipelago, who was changed into an Eagle, and made a Constellation: and by others to have been the Eagle, which Jupiter sent to convey Ganymedes,* son of Tros, king of Troy, from Mount Ida, when he made him his cup-bearer instead of Hebe.

Antinous, was a youth of Bithynia, in Asia Minor, and a great favourite of the Emperor Adrian; who perpetuated his name by erecting a temple to his memory; and by having him placed among the Constellations. Aquila and Antinous are considered as forming one Constellation; consisting of 71 Stars, viz. Altair in the neck of the Eagle, of the first magnitude, ten of the third, three of the fourth, and the rest smaller. Altair rises E. by N. and may be seen in the evenings from the beginning of June till December.

Delphinus, *the Dolphin,* was made a Constellation by Neptune, who, by means of a Dolphin, obtained Amphitrite for his wife. She was the daughter of Oceanus and Tethys, and Goddess of the Sea.

This Constellation contains 18 Stars, viz. five of the third magnitude, four of which form a Diamond, and are conspicuously situated a little to the eastward of Altair; the rest being very small. They rise in the E.N.E., and may be seen every evening from June to the end of the year.

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* See the Constellation Aquarius.

Vulpecula et Anser, *the Fox and the Goose*, a new Constellation formed by Hevelius, containing 37 Stars; none of them larger than the fourth magnitude: it rises in the N.E. and continues visible every evening from May till January.

Aquila et Antinous crosses the Equinoctial east of Taurus Poniatowski, having Delphinus on the east, and Vulpecula et Anser on the north. Sagitta, which was described with Hercules, lies between Vulpecula and Aquila.

SOUTHERN CONSTELLATIONS.

ORION, LEPUS, CANIS MAJOR, CANIS MINOR, AND MONOCEROS.

Orion is represented by the figure of a Man, with a huge Club in his right hand, and in his left the skin of a Lion for his shield. He was a famous hunter, and accompanied Diana to the chase. He was at last killed by her, with an arrow in mistake, or as some say, by a Scorpion* which she raised out of the ground; either for his improper conduct, or for boasting that no beast whatever could escape him. The Goddess however, requested Jupiter to place him among the Stars.

This Constellation is the most brilliant in the Heavens, and contains 78 Stars, viz. Betelguex and Rigel of the first; Bellatrix and three others in the belt, of the second; Saiph and two others, in the sword of the third; and fourteen of the fourth magnitude, the rest being more diminutive. It rises due east, and first makes its appearance, at eight o'clock in the evening, about the middle of November, and continues visible every evening till April.

Lepus, *the Hare*, was said to be placed near Orion, because it was an animal which he was particularly fond of hunting.

It contains 19 Stars: three of which are of the third magnitude, forming a right angled triangle; seven of the fourth, and the rest of smaller magnitudes. It rises in the S.E. by S., and though it accompanies Orion, yet, it is not seen so early, or so late in the year or in the evening, as that Constellation is.

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* See the Constellation Scorpion.

Canis Major, *the Great Dog*, is supposed by the Greeks, to have been one of Orion's hounds, but others imagine that it had its origin from the Egyptians; who always judged of the rising of the Nile, by the heliacal rising* of Sirius, its principal Star; which took place in Egypt, in the time of Hesiod, about the end of June. It contains 31 Stars, viz. Sirius of the first magnitude; two of the second; four of the third, and four of the fourth. It rises in the E.S.E. and may be seen in the evenings from January till April. Sirius is the most brilliant Star in the universe, for which reason, it is supposed to be the nearest to the Earth.

Canis Minor, *the little Dog*, is, also by the fabulists, supposed to be one of Orion's hounds; but it is more than probable that it originated with the Egyptians, and for the same reason as Canis Major, as the chief Star in each Constellation, viz. Sirius and Procyon rise heliacally, at the same time to them.

It is a small Constellation consisting of 14 Stars; Procyon, its principal Star, is of the first magnitude, it is accompanied by one of the third magnitude, about five degrees N.W. of it, and by which it may always be known. The rest are scarcely visible to the naked eye. Procyon rises E. by N. about an hour before Sirius; and may be seen every evening from the beginning of the year till May.

Monoceros, *the Unicorn*, is one of the Constellations which were formed by Hevelius out of the Stella Informes of the ancients. It is situated between Canis Major and Canis Minor; and consists of 31 Stars; only nine of which are so large as the fourth magnitude. The three forming a line near Betelguex in Orion, are in his head. It rises and sets a little before, and after, Sirius in Canis Major.

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* A Star is said to rise heliacally, when it is seen in the morning, just emerging from the rays of the Sun, after being in conjunction with him.

Orion is situated on the Equinoctial, having Aries and Taurus on the N.W.; Gemini on the N.E.; Canis Major on the S.E.; Canis Minor and Monoceros on the East, and Lepus on the South.

If we attend to the attitudes of the several Constellations in this association, we shall find Taurus in the act of making an attack upon Orion, in order to protect the Pleiades* from his further importunities; but who appears to be well prepared to meet the infuriated beast, having his Club raised ready to strike the fatal blow: and whilst Canis Major appears to be engaged as a watch over the Hare at his feet, we find Canis Minor stepping forward to assist his master in the combat. The Ram, looks back upon the contending party with little or no concern; but the Twins are evidently clasping each other in fearful agitation, and seem to be consulting on the best means of escape.

HYDRA, SEXTANS, CRATER, CORVUS, ARGO NAVIS, PYXIS NAUTICA, AND ANTLIA PNEUMATICA.

Hydra, *the Water Snake,* according to fabulous history, was the Serpent of seven heads, that infested Lake Lerna in Peloponnesus; which was killed by Hercules in one of his twelve labours.

It contains 60 Stars, viz. Cor Hydra of the second magnitude; two of the third; and twelve of the fourth; the rest being of inferior magnitudes. Cor Hydra its chief Star rises in the E.S.E. and is visible every evening from the middle of January till June.

Sextans, *the Sextant.* A nautical instrument for taking the angular distance of Celestial objects, and is principally used in taking Lunar observations; it is one of the Constellations made by Hevelius out of the Informes of the ancients; and contains 41 Stars; only one of which is of the fourth magnitude. It rises with Cor Hydra, and sets a little after that Star, and may be known by its lying between Cor Hydra and Regulus in Leo.

Crater, *the Cup,* is a small Constellation containing 31 Stars, viz.

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* See the Pleiades in the Constellation Taurus.

eight of the fourth magnitude, and the rest smaller. It rises in the E.S.E. and is visible in the evenings from the beginning of March till June.

Corvus, *the Crow.* The Mythologists inform us that, Apollo killed his beloved wife Coronis, in a fit of jealousy, which was occasioned by the indiscreet prattling of a Crow, the white feathers of which he changed into black, and afterwards placed it among the Constellations. It consists of only nine Stars, three of which are of the third magnitude, forming an isosceles triangle.* It rises in the E.S.E. and may be seen every evening from the middle of March till June.

Argo Navis, *the Ship Argo*, in which Jason, son of Æson, king of Thessaly, and his forty-nine heroes, sailed to Colchis, for the Golden Fleece of the Ram. It is supposed to have been the first ship of war, and built by Argus for the purpose of this expedition. Hercules, Orpheus, Castor and Pollux were among the crew.

It is composed of 64 Stars, viz. Canopus and another, of the first magnitude; six of the second; ten of the third; and twelve of the fourth. Only two Stars, in the prow, of the third magnitude, are visible in the latitude of London; they rise in the S.E. and may be seen on the East of Canis Major, every clear evening from January till April.

Pyxis Nautica, *the Mariners' Compass*, is a modern Constellation, applied to the mast and rigging of Argo Navis, consisting of four Stars, according to Flamsted's Catalogue; but nine are laid down on the Globes, only two of which are so large as the fifth magnitude. In consequence of which, and their nearness to the Horizon, they can seldom be seen.

Antlia Pneumatica, *the Air Pump*, is a new Constellation formed from the ancient Sporades, south of Hydra. It contains a few very small Stars, the principal one being of the fifth magnitude, situated east of Pyxis Nautica, and though it partly rises above the horizon; yet it cannot be seen without a telescope.

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* A triangle having two equal sides.

The head of Hydra is about fifteen degrees east of Procyon in Canis Minor, whence it extends about ninety degrees eastward, and nearly parallel with the Ecliptic; having Sextans, Crater, and Corvus on the north, and Argo Navis, Pyxis Nautica, and Antlia Pneumatica on the south.

CENTAURUS AND LUPUS.

Centaurus, *the Centauri,* are said to be the offspring of Ixion, and a cloud, which Jupiter caused to appear before him in the form of Juno. They were monsters, half men and half horses, inhabiting Thessaly till vanquished by Theseus, son of Algeus and Æthra, who was considered the next hero to Hercules.

The Constellation contains 35 Stars, viz. two of the first, in the fore feet, one of the second in the left shoulder, seven of the third, and eight of the fourth magnitude; of which only the one of the second magnitude in the left shoulder, one of the third in the right shoulder, and four others of the fourth magnitude, in the head, rise in the latitude of London; and even these are too near the southern horizon to be seen, except on a very clear evening in the month of June.

Lupus, *the Wolf,* is one of the ancient Constellations, consisting of 24 Stars, viz. three of the third, and four of the fourth magnitude. The head of Lupus rises in the S.S.E. but the Stars are so small, and so near the horizon that they cannot be seen in this country.

Centaurus is situated on the south of Libra, having Lupus on the east of him; he is holding the Wolf by the fore leg, and running him through with his spear.

MICROSCOPIUM, PISCES AUSTRALIS, AND APPARATUS SCULPTORIS.

Microscopium, *the Microscope,* is a modern Constellation, near the hind feet of Sagittarius, to which it formerly belonged.

It contains about 10 very small Stars. Though a small part of it rises in the S. S. E. yet it is not often visible to the naked eye, in the latitude of London.

Pisces Australis, *the Southern Fish,* is supposed by the Greeks to have been the Fish, into which Venus transformed herself in order to escape from the Giant Typheus, whom Juno produced by striking the ground.

It contains 24 Stars, of which Fomalhant is of the first magnitude, two of the third, and six of the fourth. Fomalhant rises S.E. by S. and may be seen, very near the horizon, in the evenings of October and November.

Apparatus Sculptoris, *the Sculptor's Apparatus,* is a new Constellation, made by M. De la Caille, a celebrated French astronomer, consisting of about 12 Stars; but too minute to be seen in Great Britain.

Pisces Australis is on the south of Aquarius, near his feet; having Microscopium on the west, and Apparatus Sculptoris on the east.

CETUS, ERIDANUS, BRANDENBURGIUM SCEPTRUM, AND FORNAX CHEMICA.

Cetus, *the Whale.* This is the sea monster that was intended to devour Andromeda, the daughter of Cepheus and Cassiopeia; but it was metamorphosed into a rock, by Perseus,* who accomplished this wonderful exploit, by shewing it the head of Madusa.

It contains 97 Stars, viz. Mencar, on the upper jaw, of the second magnitude; Deneb Kaitos, and Baten Kaitos, with six or seven others, of the third, and ten of the fourth magnitude, the rest being smaller.

Baten Kaitos, in the body, rises in the E. S. E. and continues visible from September till February.

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* See the Constellations of Cepheus, Cassiopeia, &c.

ERIDANUS, *the River Po.* The Mythologists inform us, that Phaëton, son of Sol and Clymene, presumptuously undertook to guide the chariot of the Sun, his father, for one day; when the horses, not being accustomed to their driver, took fright; the charioteer was so dazzled with the splendour of the light above, and so terrified by the depth of the abyss beneath him, that he let go his reins, lost his way, and would have set the whole world on fire, had not Jupiter struck him with a thunderbolt into this river.

It contains 84 Stars, viz. Achernar of the first magnitude, in the southern extremity, one of the second, Theemini and nine others of the third, and twenty-four of the fourth. The principal part of this Constellation rises between the East and S.E. and is visible every evening from November till March. Achernar its chief Star never appears above the horizon of London.

BRANDENBURGIUM SCEPTRUM, *the Sceptre of Brandenburg,* is a small Constellation, consisting of three or four Stars, viz. two of the third magnitude, one of the fourth, and another adjoining it, of the fifth. It is included in that of Eridanus, and forms a line perpendicular to the equinoctial line.

FORNAX CHEMICA, *the Chemical Furnace,* a new Constellation made by M. De la Caille, containing about 14 Stars of an inferior magnitude, which are seldom visible to us, on account of their nearness to the horizon.

Cetus occupies the largest space of any Constellation in the heavens. It is situated partly on the equinoctial line, having Pisces and Aries on the north; Eridanus and Brandenburgium Sceptrum on the east; Fornax Chemica, and Apparatus Sculptoris, on the south; and Aquarius on the west.

CELA SCULPTORIA, AND COLUMBA NOACHI.

CELA SCULPTORIA, *the Graver's Tools,* is a modern Constellation, containing 16 Stars, four being of the fifth magnitude, and the rest smaller. A small part of this Constellation rises above the horizon of London, but none of its Stars are visible.

COLUMBA NOACHI, *Noah's Dove,* is also a new Constellation, consisting of 10 Stars, viz. one of the second magnitude, one of the third, and two of the fourth.

Its chief Star rises in the latitude of London, but is too near the horizon to be seen.

These two Constellations are on the south of Lepus, having Canis Major on the east, and Eridanus on the west.

DESCRIPTION OF THE GLOBES, &c.

There are two artificial Globes; one of them being a representation of the Earth, and the other that of the Heavens; the former is called the Terrestrial, and the latter the Celestial Globe.

On the Terrestrial Globe are delineated, the Continents, Islands, Seas, Gulfs, Lakes, and Rivers, as they naturally exist on the Earth; together with the boundaries of the several Countries and Kingdoms into which the World is politically divided, and the positions of the Cities and principal Towns which have been erected on its surface by the art of man.

On the Celestial Globe, the Fixed Stars are laid down so as to retain the same relative position with respect to each other as they naturally possess in the Heavens.

The figures of the Constellations are also delineated on its surface. These figures being lightly coloured, have a very pleasing effect to the eye, and are calculated to impress the names of the Constellations more permanently on the mind.

Geographers and Astronomers suppose several Lines and Circles to be drawn on the Earth, and in the Heavens, by which they determine precisely the situation of places on the former, and the position of the Stars in the latter.

These Lines and Circles are actually drawn on the artificial Globes.

They which are on the Terrestrial Globe are the Equator, Parallels of Latitude, Meridians, Tropics, Polar Circles, and Ecliptic.

They which are on the Celestial Globe, are the Equinoctial, Tropics, and Polar Circles; Ecliptic and Zodiac; Parallels of Celestial Latitude, and Circles of Celestial Longitude.

If the Student be not in possession of the Globes, he is requested to refer, whilst reading the following definitions, to the Maps of the World, which may be found in every Geographical Atlas, and in almost every Treatise on Geography. These Maps consist of two distinct views of the Terrestrial Globe, usually entitled the Eastern, and the Western Hemisphere.

A Great Circle is that which divides the Earth or Heavens into two equal parts.

A Small Circle is that which divides the Earth or Heavens into two unequal parts.

Every Circle, whether great or small, is supposed to be divided into 360 equal parts, called degrees ; and each degree is subdivided into 60 equal parts, called minutes or miles; therefore, a Semicircle contains 180 degrees, and a Quadrant 90 degrees. The degrees are distinguished by a small circle (°), and the minutes by a dash(′) ; thus 51° 30′ means 51 degrees 30 minutes.

The Graduated Circle, surrounding the Map, represents the Brass Meridian, within which the Globe is suspended by two pivots fixed in the poles. By these means it may be turned round to imitate the diurnal motion of the Earth. The four quarters or quadrants of this circle on the Maps are numbered from the Equator towards each Pole; but the Brass Meridian of the Globe, has one side numbered from the Equator towards each Pole, and the other side, from the Poles towards the Equator.

The Axis of the Earth, is an imaginary line passing through its centre, on which it is supposed to turn, and is represented by the perpendicular line passing through the centre of the Map; the extremities of which are the Poles, the upper one being the North Pole, and the lower one, the South Pole.

The Equator is that great circle which circumscribes the Earth, and is equally distant in all its parts from the Poles. It divides the Earth into the Northern and Southern Hemispheres. This circle is represented on the Maps by a straight line passing through the centre at right angles with the Axis, aud terminating at 0 on both sides of the circumference.

The Situation of a Place on the Earth, is determined by what is termed its Latitude and Longitude.

The Latitude of a Place is its distance, reckoned in degrees and minutes, to the North and South of the Equator, and can never exceed 90 degrees, that being the distance of the Poles from the Equator. This may be clearly understood by referring to the graduated circle of the Map.

The Longitude of a Place is its distance reckoned in degrees and minutes, to the East and West of some noted Meridian, as that of Greenwich, and can never exceed 180 degrees, which is half the circumference of the earth. The Longitude is counted on the Equator, which is numbered both ways from the Meridian of Greenwich.

Parallels of Latitude are small circles parallel to the Equator, and are drawn on the Maps and Globes through every tenth degree of Latititude. Places lying due east and west of each other, are said to be in the same parallel of Latitude.

Meridians are Semicircles drawn from pole to pole, through every fifteenth degree of the Equator; consequently, there are 24 of them, which correspond with the 24 hours of the day: but on the Maps of the World, they are drawn through every tenth degree.

The Tropics are two small circles parallel to the Equator, and at the distance of 23 degrees and a half from it; one of them being on the north, called the Tropic of Cancer; and the other on the south, called the Tropic of Capricorn. The space included between the Tropics is called the Torrid Zone.

The Polar Circles are two small circles parallel to the Equator, and at the distance of 66 degrees and a half from it, or 23 degrees and a half from the poles. That near the north pole is called the Arctic Circle; and that near the south pole, the Antarctic Circle. The spaces included between the tropics and polar circles, are called the Temperate Zones; and those included by the polar circles, the Frigid Zones.

The first and second moveable Plates, are delineations of the Celestial Globe, consisting of two Parts or Hemispheres, the convex side being next to the eye. They contain all the Circles as well as the Figures of all the Constellations usually drawn on that instrument. The Student will therefore refer to these Plates whilst reading the following definitions.

If we suppose the Axis of the Earth to be continued to the Heavens, it will terminate in the Celestial Poles, or those points in the Heavens about which the Stars appear to revolve.

The Equinoctial is the Equator supposed to be continued to the Heavens. It is so called, because, when the Sun is in the Equinoctial points, the Days and Nights are equal to every part of the World; which happens twice in the year, viz. about the 21st of March, and the 23d of September; the former is called the Vernal Equinox, and the latter the Autumnal Equinox.

The Tropics and Polar Circles correspond with those on the Terrestrial Globe. These Circles are engraved deeper on the plates, in order to distinguish them from the other circles of the Celestial Sphere.

The Declination of a Celestial Object is its distance, computed in degrees and minutes, to the North or South of the Equinoctial; and corresponds with the latitude of a place on the Terrestrial Globe.

Parallels of Declination are small circles parallel to the Equinoctial. They are the parallels of latitude supposed to be continued to the Heavens, but they are not expressed on the Globes.

The Right Ascension of a Celestial Object is that degree of the Equinoctial which comes to the Meridian at the same time as the object; and is reckoned eastward from the first point of Aries.

The Celestial Meridians are semicircles drawn from one celestial pole to the other; and are the Terrestrial Meridians supposed to be continued to the Heavens. They are not delineated on the Globe, but are represented by the Brass Meridian.

The Colures are two great circles or meridians passing through the celestial poles, cutting each other at right angles. One of them, passing through the equinoctial points Aries and Libra, is called the Equinoctial Colure; and the other, passing through the solstitial points Cancer and Capricornus, is called the Solstitial Colure. They divide the Ecliptic into four equal parts of three signs each, and mark the four Seasons of the year. Thus, the point Aries (♈) in the centre of the first plate, is called the Spring Equinox; and that of Libra (♎) in the second plate, the Autumnal Equinox: the point Cancer (♋), is termed the Summer Solstice; and that of Capricornus (♑), the Winter Solstice. The Solstitial Colure divides the Globe into the two Hemispheres, which are represented by the Plates; consequently the circumference represents the Solstitial Colure; and the Line which passes through the points ♈ and ♎ from pole to pole, represents the Equinoctial Colure.

The Ecliptic marked ♑ ♒ ♓ ♈ ♉ and ♊ in the first plate, and ♋ ♌ ♍ ♎ ♏ and ♐ in the second plate, is the *apparent* annual path of the Sun among the Stars; or, properly speaking, it is the *real* path of the Earth* extended to the Starry Heavens. It crosses the Equinoctial, and forms an angle with it of about 23 degrees and a half. The points of intersection, marked ♈ and ♎ are called the Equinoctial points.

The Zodiac is a space including about 8 or 10 degrees on each side of the Ecliptic, and encompasses the Heavens like a belt or girdle. It is divided into 12 equal parts of 30 degrees each, called the Signs of the Zodiac. It may be easily known in the plates, by tracing the figures of the signs; or by the characters which are used to represent them: for the names and order of which, see the table of Zodiacal Constellations, page 7.

The Poles of the Ecliptic are those points in the Heavens which are 90 degrees from every part of the Ecliptic; being 23 degrees and a half from the Celestial Poles.

The Latitude of a Celestial Object is its distance to the North or South of the ecliptic; reckoned on a great circle passing through the poles of the ecliptic. The Sun, being always in the ecliptic, has no latitude.

Parallels of Celestial Latitude are small circles parallel to the ecliptic. They are drawn on the Globe through every tenth degree of latitude.

The Circles of Celestial Longitude are great circles passing through the poles of the ecliptic, and cutting it at right angles. They are drawn on the Globe through every 15 degrees of the ecliptic.

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* This is familiarly explained in the Description of the Third Moveable Plate.

The Longitude of a Celestial Body is its distance, computed in signs, degrees, and minutes, to the East of the first point of Aries; or of that circle of celestial longitude which passes through that point. The Sun's Longitude is sometimes called the Sun's Place.

Circles of Perpetual Apparition are small circles parallel to the Equinoctial; the distance of which from the *elevated* pole is equal to the latitude of the place. Thus, that of London is 51 degrees and a half from the North Pole. The Stars within it are called Circumpolar Stars, being they which never set in that parallel of latitude. It is represented on the Maps by the inner circle, touching the north point of the horizon.

Circles of Perpetual Occultation are small circles parallel to the Equinoctial; the distance of which, from the *depressed* pole, is equal to the latitude of the place. That of London, of course, is 51 degrees and a half from the South Pole. The Stars within it never rise to places in that parallel of latitude. These two circles are represented on the plates by dotted lines, drawn between the Tropics and Polar Circles.

The Horizon is either Rational or Sensible.

The Rational Horizon is a great circle, which divides the Starry Heavens into the upper and lower hemispheres; the Stars in the upper, being those that are visible; and in the lower, those that are invisible to us. It also determines the rising and setting of the Sun, Moon, and Stars; and is represented by the Wooden Horizon of the Artificial Globe.

The Sensible Horizon is that circle which terminates our view, when the objects we are looking at are upon the surface of the earth. When the eye of a spectator is elevated above the level of the sea, he not only sees surrounding objects more distinctly, but those also which are more remote, the higher he ascends.

The top-mast of a ship 100 feet high can be seen by a person whose eye is elevated 6 feet above the level of the sea, at the distance of 14 miles. If he ascends to the top of a hill 80 feet high, he can see the same object at the distance of 22 miles, and still farther the more he is elevated.

The Earth being a spherical body, the horizon or limits of our view must necessarily change as we change our station.

The Zenith is that point in the Heavens which is directly over the spectator's head, and is 90 degrees from every part of the horizon; consequently it must be in the elevated pole of the horizon.

The Nadir is that point of the Heavens which is directly under the spectator's feet, and is diametrically opposite to the Zenith; consequently it must be in the depressed pole of the horizon.

Azimuth or Vertical Circles are great circles passing through the Zenith and Nadir.

An Arc of a Circle is any part of a circle. An imaginary line supposed to be drawn from the zenith to any part of the horizon is an Arc of a vertical circle containing 90 degrees.

The Zenith Distance of a Celestial Object is the distance of its centre from the zenith, and is reckoned upon the arc of a vertical circle which passes through the centre of the object.

The Meridian of a Place is a great circle which passes through the celestial poles, the zenith, and the south part of the horizon.

The Altitude of a Celestial Object is the elevation of its centre above the horizon, and is reckoned upon the arc of a vertical circle which passes through the centre of the object.

The Meridian Altitude of a Celestial Object is the elevation of its centre above the horizon, when the object is on the meridian, or due south.

When a Celestial Object is due south it is then at its greatest elevation above the horizon. The Sun, when in that situation, is said to be on the Meridian; the Moon to South; and the Stars to Culminate.

Apparent Time is that shewn by a Sun Dial.

Mean Time is that shewn by a well regulated Clock.

Equation of Time, is the difference of time between that shewn by a Sun Dial, and a well regulated Clock. There are only four days in the year, when the Clocks agree with the Sun Dial; viz. about the 15th days of April and June, the 1st of September, and the 25th of December. The greatest difference happens on the following days; viz. about the 10th of February, when the Clock is nearly fifteen minutes faster than the Sun Dial; the 12th of May, when the Clock is about four minutes too slow; the 25th of July, when the Clock is six minutes too fast;—and the 3d of November, when the Clock is sixteen minutes slower than the Sun Dial.

THE

FORM, MEASUREMENT, AND MAGNITUDE OF THE EARTH.

THE first step the Student ought to take in order to acquire a practical knowledge of Astronomy, is to obtain a clear idea of the form, magnitude, and motions of the Earth; and of the general appearance of the Heavenly Bodies as seen therefrom. I shall therefore endeavour to prove the Sphericity of the Earth, and shew the method by which Astronomers ascertain its magnitude; and then treat of its motions and of the appearances thence arising.

The most simple and convincing proofs we have of the Rotundity of the Earth, are the several voyages which have been made round it by Magellan, Drake, Anson, Cook, and others.* These circumnavigators took their respective departures from Europe, and sailed on a Westerly course, round Cape Horn, until they returned by the Cape of Good Hope, to the several ports from whence they departed. Now we are certain that these voyages could not have been performed, if the Earth were in the form of an extended Plane, as the ancients supposed it to be; for then, if a Ship were to sail from any assigned port and continue to sail towards the same point of the horizon, she would never return to that port, but would continue to increase her distance from it, as long as she should continue on that course.

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* The following is an account of a Voyage recently made round the World, in the Ship Coronet, Captain T. B. Daniel, of Hastings; who very kindly allowed me to extract it from his journals. The Coronet left England April 3, 1828, and arrived at Madeira May 12;—passed by Cape Verd Islands May 24, and arrived at Rio Janiero July 1; from whence she sailed July 10;—passed by St. Pauls and Amsterdam Islands Sept. 4; and cast anchor off Hobart's Town, Van Dieman's Land, Oct. 6. Left Van Dieman's Land for England April 29, 1829;—after sailing through the South Pacific Ocean, she came round Cape Horn June 16; and put into Pernambuco, coast of Brazil, July 31. Sailed from thence Aug. 15;—passed by the Western Islands Sept. 20; and arrived in the British Channel Oct. 6, 1829: having been absent about 18 months. Her track may be easily traced on a Terrestrial Globe, or on a Map of the World.

The Rotundity of the Earth, from east to west, is also proved by the rising of the Sun; which takes place one hour earlier to those who live 15 degrees eastward, and one hour later to those who live 15 degrees westward, than to us. For, if the Earth were a plane, the Sun would rise to, and enlighten all the Earth at the same instant; as may be proved by an easy experiment made with a lighted Candle and a Table. Thus, if the candle is gently raised from the floor till it just begins to throw its light upon the upper surface of the table, it will be seen, that every part of the table is enlightened at the same instant. But if a similar experiment is made with the Candle and Terrestrial Globe, the reverse will be the result; for the candle being gently raised on the east side of the globe, in imitation of the Sun rising; it will be found that, as the candle or artificial sun rises, the places situated on the west will be brought into the light; or, in other words, the Sun will appear to rise to their inhabitants, one after the other as in nature.

That the Earth is round also from north to south is proved by the elevation or depression of the Stars. If a Ship sail northward in the northern hemisphere, the mariners on board will observe the North Pole Star to be more and more elevated, the farther they proceed to the north; whilst those in the south are gradually depressed till they disappear below the horizon. On the contrary, if a Ship sail southward, the Stars in the north will be depressed, whilst those in the south will be more elevated, and others will gradually appear above the horizon, which were invisible to those on board in their former situation.

And that the Earth is round in every direction is proved by the appearance of Ships departing from, or approaching to the land; for instance, suppose a person standing on the sea coast, looking out for a ship, which he is expecting to arrive; with the assistance of his telescope he at length discovers her, with her top-sails just appearing above the horizon, whilst her hull is hid from his sight by the convexity of the water; as the Ship approaches the land, he sees more of her sails, till by degrees the hull is presented to his view. On the contrary, if the Ship were departing from the land, he would first lose sight of the hull; at a greater distance, the lower sails, then the top-sails; and at a still greater distance, she would wholly disappear. But, if the surface of the sea were a plane, the hull of the Ship being the largest part, would be seen first when the Ship was approaching to, and last when departing from, the land.

To illustrate this by an experiment, draw the outline of a Ship on a card, and cut away all the superfluous parts. Place this ship on a table, and get an assistant to move it slowly to the opposite side, in imitation of a ship sailing on a plane; it will then appear evident that the whole of the ship may be seen, however distant she may be, and that, whether you are standing on a chair or on the floor. Again, let the assistant place the ship on a Terrestrial Globe, or any other spherical body, and move it slowly round till the hull is hid from your sight by the convexity of the globe, then ascend a chair, and the hull will become visible again.

Sailor boys have a custom, in order to display their dexterity, in ascending to the mast head as soon as they lose sight of the upper limb of the setting Sun on deck, of running up the rigging, and by that means catch another glimpse of the departing Luminary of the day. Thus, distant objects are brought into view, in proportion to the height of the observer's eye; whether his attention be directed to lofty Spires on land, to Ships at sea, or to the Sun in the firmament.

The loftiest mountains, which are at least four or five miles high, no more affect the roundness of the Earth than grains of sand do that of an eighteen inch Globe.

Although the facts already stated, clearly prove the globular shape of the Earth; yet, further evidence will be found in those pages in which the eclipses of the Moon are treated of: to which the reader is referred.

It is necessary, however, to observe, that though we call the Earth a globe, and, in general terms, it is considered as such; yet, in the strictness of truth, it is not a perfect sphere, but what is called an Oblate Spheriod; that is, a Sphere a little flattened at the poles: the equatorial diameter being about 35 miles longer than the polar diameter.

This difference, however, bears too small a proportion to the whole diameter to be represented on the Artificial Globes.

Young persons, in general, find it very difficult to conceive how it is possible for people to stand on the opposite side of the Earth; for they suppose themselves to be on the upper part of it, and wonder how their Periœci and Antipodes* can stand with their heads hanging downwards; little thinking that they themselves are carried, by the rotation of the Earth on its axis, into one of these situations in the space of twelve hours.

Let *a* (PLATE I.) be an inhabitant of Padang in Sumatra, and *o* his Antipode an inhabitant of Quito in South America. Each of these inhabitants is surprised that the one opposite to him can stand upon, what he imagines to be, the under side of the earth. But we know that the people who live at these places, and those also who live in any other part of the world, feel no inconvenience whatever in that respect; but stand as firmly there as we do here.

For the Earth by its attraction, acting on all bodies according to their densities or quantities of matter which they contain, without any regard to their bulks, causes all bodies on its surface to fall towards its centre; not because the whole force of attraction is accumulated there, for it is the whole Earth that is the attracting mass; but, because the greatest quantity of attracting matter, or mass of Earth, is in that direction. Therefore, the inhabitant *a* is most attracted towards his Antipode *o*; and for the same reason, *e* is most attracted towards *u*; *n* towards *s*; and *i* towards *v*.

There is no such thing as an upper or an under side of the Earth, for the general surface is the top; and the centre its general bottom. An artificial Globe has an upper and an under side; hence, when we look at it, we are apt to conclude that it is as impossible for our Antipodes to stand on the Earth with their feet towards ours, as it would be for little artificial men to adhere to the under part of that instrument, which would, of course, fall to the ground as soon as they were left to themselves; for the Earth, by its superior attraction, pulls every loose body away from that side which is next to it; but there is no larger body so near the Earth as to overcome its attraction, which extends even to the Moon, and keeps her in her orbit. Therefore, there can be no such thing as an upper or an under side, and the inhabitants of the Earth can stand or move, and all loose bodies remain equally as well on one side as upon another.

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* Periœci are those who live in the same parallel of latitude, but under opposite meridians: as *e* and *i*. Antipodes are those who live diametrically opposite to each other: as *a* and *o*.

To illustrate this a little farther, we will suppose an artificial Globe to be made of solid Magnet, and a number of little figures of a light substance, with iron sandals, to be its inhabitants. You might then place these little men upon all sides of the Magnetic Globe without fear of their falling off, for the magnetic attraction of the artificial Globe would overcome the attraction of the Earth, when acting upon bodies containing so little matter. If either of these artificial men were to be removed from the Globe to a little distance, so as to be within the power of its attraction, it would fall to the Globe again; but, if a larger Magnetic Globe were to be placed near to the smaller one, so as to overcome its attraction, it would pull every thing away from that side of the small globe next to it, and only those on the opposite side would remain upon it. Again, suppose the little globe to represent the Earth, and the larger one the planet Jupiter; it is evident that Jupiter, being the larger body, would draw us and every thing else from that side of the Earth next to it.

If the Earth were at rest, its form, by the laws of gravitation, would be that of a perfect sphere; for that is the only state in which the particles composing the Earth, which mutually attract and gravitate towards each other, could remain in equilibrium. This is familiarly exemplified by drops of water, or of quicksilver, the particles of which always dispose themselves, by the very same laws, into a spherical shape.

But as the Earth revolves about its axis, the particles of which the Earth is composed, will move in circles, the planes of which are perpendicular to the axis, whilst the poles or extremities of the axis are at rest. All bodies moving in circles have a tendency to fly from the centre, which is technically termed the centrifugal force; and this force increases in proportion to the velocity of the revolving body. As the circles which the component parts of the Earth thus describe, increase from the poles towards the equator, and as they are all described in the same time: viz. in one complete revolution of the Earth about its axis, it is evident that the centrifugal force will be greater at the equator than at London, and still greater than at Petersburgh; consequently the centrifugal force will diminish the gravity or centripetal force, which causes all the particles of a body to have a tendency towards its centre in the same proportion.

The Earth, therefore, being made of yielding materials, will gradually swell out from the poles, towards the equator; where it will be highest, because the centrifugal force is there the greatest. Again, the gravity or centripetal force is always directed towards the centre; therefore, it is at the equator only, where the centrifugal force is directly opposite to that of the centripetal: in every other part of the earth (the poles excepted), the former acts against the latter in an oblique direction.

Thus, the particles about *a* and *o* (Plate I.) are attracted towards the centre ♈, and as they move in the equatorial circle *a* ♈ *o*, the plane of which passes through the centre, they will be thrown off in a line directly opposite to the centripetal force, hence the gravity of the particles about the equator will be diminished.

The particles about *e i* and *v u*, are attracted towards the centre also, but, as the planes of the circles *e i* and *v u*, in which they move, are parallel to the equator, the particles there will be thrown off in a line parallel to the equator; or which is the same thing, in a line perpendicular to the axis.

To illustrate this, draw a line with a pencil, or imagine one to be drawn, from *e* to *i*, and prolong it to a little distance beyond *i*; draw another line also from *i* to ♈, then will the prolonged part of the line *e i* represent the direction of the centrifugal force of the particles at *i*, and the line *i* ♈, that of the centripetal or gravitating force of those particles.

Now, as the direction in which these two forces act, are oblique to each other, the particles at *i*, which are affected by them, will obey neither, but will move in a line between them, tending towards the equator. It is evident, therefore, that the particles between the equator and the poles will press towards, and accumulate about the equator, consequently the equatorial diameter will be increased.

The poles being at rest, with respect to the diurnal motion, the particles there will have no centrifugal force to diminish their gravity; but they will gravitate more towards the centre in order to restore an equilibrium,* and by that means will produce a flatness about the poles; consequently, the polar diameter will be decreased. The Earth, therefore, under these circumstances, will assume the form of an oblate spheroid.

As the centrifugal force decreases from the equator towards the poles, where it ceases; so the gravity, being less disturbed by that force, increases from the equator towards the poles, where it is greatest. It is evident, therefore, from these two causes, that bodies are lightest at the equator, and gradually increase in their weight or gravity as they approach the poles, where they are heaviest.

The truth of this has been verified by the experiments which have been made on pendulums of equal lengths, the vibrations of which were found to be retarded in proportion to their approach towards the equator, where they were found to be slowest; and accelerated in proportion to their approach towards the poles, where they are quickest; hence a pendulum at or near the equator, must be made shorter if it be required to beat equal time with another fitted to beat seconds in the latitude of London, because the gravity which produces the vibrations, is less there than at London. The experiments made on the vibrations of the pendulum, therefore, is another and a very strong proof of the oblate spheroidal figure of the Earth.

As most of the Planets are observed to have a rotary motion about their axis, similar to that of the Earth, it was reasonable to conclude that they should exhibit a similar appearance as to their shape also; for similar causes will produce similar effects. This appearance has actually been observed to exist in those Planets, and especially the Planet Jupiter.

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* For a similar reason, the Polar diameter of the Earth, though the shorter, contains more matter than the Equatorial diameter.

By measuring the two diameters of that Planet with a micrometer, the proportion of the polar to the equatorial diameter was found to be as 12 to 13, which is a much greater difference than that of the Earth, because the rotation of that Planet is quicker, his diurnal motion being completed in the short space of 9 hours and 56 minutes; which is more than double the velocity with which the Earth revolves on its axis.

The elipticity of the Earth is also proved by an actual measurement of a degree of the meridian in different latitudes, which is found to increase from the equator to the poles. For, if the Earth be flattened at the poles, those parts of the meridian which are near the poles, must be portions of larger circles than those near the equator. It has already been observed, that every circle is supposed to be divided into 360 equal parts or degrees; the length of the degrees then, must depend entirely on the size of the circle; therefore, the degrees of the meridian near the poles being portions of a larger circle, they must be greater or longer than those near the equator, which are portions of a smaller circle.

A difference of opinion, as to the true shape of the Earth, having arisen between Sir Isaac Newton and some of the first philosophers of France, among whom was the celebrated Cassini, the former endeavouring to demonstrate by mathematical calculation, that the equatorial diameter was longer than polar, and the latter affirming, that the polar diameter exceeded that of the equatorial.

In order, therefore, to ascertain the true figure of the Earth, and by that means to determine the controversy between those philosophers, the continuance of which might have retarded the general improvement in science; the French government in the year 1735, appointed two parties, the one to go to Peru to measure a degree of the meridian there, and the other to Lapland for the like purpose. The result of their labours proved the truth of Sir Isaac Newton's opinion, for the length of a degree in Lapland was found to exceed that of a degree in Peru.

Since that period, degrees of the meridian have been measured at several places between the equator and the north pole. The following table contains the proportional lengths of a degree in English miles, &c. which have been selected from the best and most recent authorities, viz.

Country.	*Latitude.*	*Length of a Degree.*	
		Miles and parts.	*Miles. fur. poles.*
Peru	Equator	68·727	68 5 32
France	45° N.	69·045	69 0 14
Lapland	66° N.	69·264	69 2 4

Hence it appears that the length of a degree in France exceeds that of a degree upon the equator by about 2 furlongs 22 poles, or more than a quarter of a mile; and it appears that a degree in Lapland is about 4 furlongs 12 poles, or a little more than half a mile longer than a degree at the equator.

If 69·045 miles be taken for the mean length of a degree between the Equator and the Poles; then by multiplying this by 360 degrees, will give 24856 miles for the circumference of the Earth; then to find the diameter, say by proportion, as 355 is to 113, so is 24856 the circumference, to 7912* the diameter of the Earth.

The method of finding the length of a degree of the meridian, may be illustrated in the following manner: Thus, count 51 degrees and a half on the Brass Meridian of the Globe, (PLATE I.) reckoning from the Equator towards the North Pole, and bring the point where the reckoning ends, to the Zenith, which will then be directly over *e* the observer's head. By counting the number of degrees contained between the North Pole and the north point of the horizon, it will be clearly seen that the elevation of the North Pole Star above the horizon, is equal to the latitude of the place of observation.

Now, if the observer were to travel to the north, until he should increase the elevation of the Pole Star five degrees, it is evident that he would have travelled over a space equal to five degrees; and if that space were to be accurately measured, it would give the length of five degrees of the Terrestrial Meridian, between the parallels of 51 and a half and 56 and a half degrees north latitude.

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* Mr. Richard Norwood was the first who ascertained the length of a degree; which he found by measuring the distance between London and York, in the year 1635. The result of his admeasurement gave 69½ English miles for the length of a degree, which being multiplied by 360 will produce 25020 miles for the circumference of the Earth; and as 355 is to 113 so is 25020 to 7964 miles for the diameter of the Earth; which is that generally given in books of Astronomy.

This may be further illustrated by Plate IV. Fig. 1: thus, let the outer circle represent the Starry Heavens, and the inner one the Earth; *e q* the Equator; E Q its corresponding circle in the Heavens; *n*, *s* the North and South Poles; N, S the Poles of the Heavens; *c* an observer in the latitude of London, 51°½ N.; *a* his Zenith, 51°½ N. of E the Equinoctial line; H O the Rational Horizon of *c*, and *h o* that of *d*; N O the altitude or elevation of the North Pole Star, as observed at *c*, which is equal to E *a* the latitude of *c*.

Now, if *c* travel northward till he arrive at *d*, and there find by an observation, that the altitude of the Pole Star is 56½ degrees above his horizon; it is evident that he has travelled over a space equal to five degrees, for O *o* or *i v* is the difference between the altitudes of the Pole Star at the two stations, and is equal to *a b* or *c d* the difference of latitude between the two observers.

Then, if the space *c d* between the two stations were accurately measured, the result would give the length of five degrees; one fifth of which would of course be the length of one, and this multiplied by 360 would give the whole circumference of the Earth, supposing it to be the mean length of a degree.

As it may appear rather difficult for young persons to comprehend how the length of an arc of a Meridian, or a direct North and South line, as *c d* Plate IV. Fig. 1, can be measured; I shall now endeavour to give them as familiar an illustration of the method by which it is ascertained, as the nature of the subject will admit.

Suppose, then, that the arc to be measured be the line A E Plate IV. Fig. 2; the difference of latitude between A and E, which gives the number of degrees contained in the arc, being previously obtained by the former method.

The first step is to choose a level plain on one side of the

Meridian, on which a base line of a few miles in extent can be accurately measured, as B C, being the only line required to be laid down by actual admeasurement. The next step is to select a number of convenient stations, as B, C, D, *e*, and *f*, at each of which I shall suppose some remarkable object to be situated, such as a Church, a House, or a Mill; and that these objects are so situated, that A, *f*, C, may be seen from the station B: D, *e*, *f*, B, from C; and E, *e*, C, from the station D. The several stations are then to be connected together by imaginary lines, which will form a series of triangles, as in the figure.

The angles of all the triangles are then to be measured by a theodolite, or other instrument adapted for measuring angles. Beginning at station B, the instrument being properly adjusted, the telescope is first to be directed to the station A; the graduated circle will then show the inclination of the line B A to the Meridian, or the number of degrees contained in the angle A B *a*; by directing the telescope to *f* and C, the angles A B *f* and *f* B C are obtained. The observer then goes to the station A, to take the angle B A *f*; thence to *f*, C, *e*, D, and E, at each of which the angles are determined in the same manner.

Having determined the quantity of all the angles; and the base line B C being known from actual measurement, the other lines or sides of the triangles are calculated by Trigonometry: Thus, to find the sides B *f* and C *f* of the triangle B *f* C, say, as sine of angle B *f* C is to side B C, so is sine angle B C *f* to side B *f*; and as sine angle B *f* C is to side B C, so is sine angle C B *f* to side C *f*. By this means, a side of two more triangles are known: viz. B *f* of the triangle A B *f*; and C *f* of the triangle B C *f*; and by proceeding in a similar way with the computations, the lengths of all the other sides are found without any further measurement in the field.

The sides A B, B C, C D, and D E, with their several inclinations to the Meridian, or the angles A B *a*, B C *b*, D C *c*, E D *d*, being known, the second series of triangles, viz. A B *a*, B C *b*, C D *c*, and D E *d* may be constructed, and their sides calculated as in the former series. It will now be evident that the sum of the sides *a* B, *b* C, C *c*, D *d*, is equal in length to the Meridian Arc A E, which was required to be measured.

THE

PHENOMENA OF THE HEAVENS

ARISING FROM THE

DIURNAL MOTION OF THE EARTH.

If the Stars which form any of the Constellations in the concavity of the Heavens, be compared with their representatives on the convex surface of the Celestial Globe, their positions will be found to be reversed; for those which appear on the right hand, when looking down upon the Globe, will be found to be on the left hand in the Heavens.

If we suppose the Celestial Globe to be made of a transparent substance, and a small Terrestrial Globe to be placed in the centre of it; then, to a spectator on the latter, the Stars on the surface of the former, would appear to him precisely as they do in the Heavens, to an observer on the Earth.

We may consider Plate I. as representing the two Globes as above described, where the Terrestrial is supposed to be seen through the transparent surface of the Celestial Globe.

Though the Earth appears so very large to those who inhabit it; yet it is reduced to a mere point, when compared with the immense sphere of the Starry Heavens, by which it is every where surrounded. Therefore, every inhabitant of the Earth, let him be where he may, as at *a*, *e*, *n*, *i*, *o*, *u*, *s*, or *v*, can see half of the Heavens at one time.

By turning the Celestial Hemisphere, (PLATE I.) round until the north pole, near the right foot of Cepheus, comes directly under the zenith, it will then clearly appear that the inhabitant *n* at the north pole can see all those Stars which are above the Rational Horizon; and that *s*, an inhabitant of the south pole, can see all those below it.

Turn the Hemisphere from left to right, until $51\frac{1}{2}$ degrees on the Brass Meridian come under the zenith; then all that part of the Starry Heavens which is above the horizon, will be visible to *e*, an inhabitant of London; whilst that part which is below it, will be visible to *u*, his Antipodes near New Zealand. Turn again until the ○ on the Brass Meridian comes to the zenith, then the Stars which are in the upper part of the Hemisphere will be visible to *a*, an inhabitant of Sumatra; whilst those in the lower part will be visible to *o*, an inhabitant of Quito in South America.

The other Hemisphere, (PLATE II.) being set in the positions respectively, as above described, will represent the other part of the Heavens, visible at the same time to the several inhabitants.

The Earth revolves on its axis from *west to east* every twenty-four hours, which causes an apparent revolution of all the Heavenly Bodies from *east to west* in the same time. It is, therefore, on account of the diurnal motion of the Earth, that the Sun, Moon, and Stars appear to rise in the east and to set in the west. But, supposing the Earth to be at rest and the Heavenly Bodies to revolve round it, the appearance would be exactly the same.

Let the small Terrestrial Globe, in the centre of PLATE I., represent the Earth, and *n s* the axis on which it turns. As the Earth revolves on its axis, the inhabitant *a* will be *brought to the east,* towards the reader, and in twelve hours, he will arrive at *o*, having been carried by the motion of the Earth, just half way round. Now, it is plain, from an inspection of the Celestial Hemisphere, that, in the former situation, he had the Stars in the Constellation of Aquila et Antinöus over his head; but in the latter, those in the Constellation of Orion.

Again, suppose the Earth to be at rest, and the Starry Heavens to revolve round it, as they appear to do, from *east to west* in twenty-four hours: then, by the apparent diurnal motion of the Heavens, the Constellation of Aquila et Antinöus, would be *carried to the west,* from the reader, and in twelve hours it would appear in the opposite part of the Hemisphere; whilst Orion would move towards the reader, and appear over the head of the inhabitant *a,* as in the former case.

THE

PHENOMENA OF THE HEAVENS

AS SEEN FROM

DIFFERENT PARTS OF THE EARTH.

As the apparent diurnal motion of the Heavenly Bodies from *east to west*, has already been proved to arise from the contrary motion of the Earth; I shall now endeavour to shew how their motions are affected by local circumstances.

The Earth being a spherical body, the horizon will change as we change our station; therefore every place on the Earth will have a *different horizon.*

The equator, therefore, and all the circles of celestial motion which are parallel to the equator, will have their planes differently inclined to the horizon, according to the part of the Earth from which they are observed. Hence the apparent diurnal motion of the Heavenly Bodies will be different, when viewed from different parts of the Earth; as may be illustrated by the following problems on the first two plates.

PROBLEM I.

TO ILLUSTRATE THE PHENOMENA OF THE HEAVENS AS SEEN AT THE POLES.

Of the Fixed Stars.

The inhabitants, if any, who live at the North Pole, have the North Pole Star constantly in their zenith, or in that point of the Heavens which is directly over their heads. Therefore, elevate the North Pole (Plate I.) 90 degrees above the horizon; the pole will then be in the zenith, and the equator will coincide with the horizon. And as the Polar Circles, the Tropics, and all the circles in which the celestial objects move, are parallel to the equator, they will also be parallel to the horizon. For this reason the inhabitants of the poles, are said to have a Parallel Sphere.

If the Hemisphere be now supposed to turn round on its axis, so as to cause the Stars on the east or right hand side, to move towards the west or left hand side, it will be easy to conceive that, to an inhabitant *n* of the North Pole, the motion of the Stars will be in circles parallel to the horizon, and that their altitudes will be equal to their distance from the Equinoctial: Thus, Betelguex in the right shoulder of Orion, will describe a circle about $7\frac{1}{2}$ degrees above the horizon; the Pleiades in Taurus about $23\frac{1}{2}$ degrees high, being on the Tropic of Cancer; Vega in Lyra at an elevation of $38\frac{1}{2}$ degrees; Capella in Auriga at the height of 46 degrees. The Pole Star will appear stationary over his head, whilst all the others north of the Equinoctial, will move in circles, which diminish in proportion to the proximity of the Stars to the Pole.

As the Stars revolve in circles parallel to the horizon, and the equinoctial being coincident therewith; it is evident that all the Stars in the Northern Hemisphere will be constantly above the horizon, and all those in the southern, constantly below it; consequently only half the Heavens will be visible at any time to the inhabitants of the poles.

Of the Sun.

Elevate the North Pole (Plate I. and II.) 90 degrees above the horizon as before, then that half of the Ecliptic which is north of the Equinoctial, will be above the horizon, and the other half below it. When the Sun, after passing through the signs Aquarius ♒ and Pisces ♓ (Plate I.) arrives at the first point of Aries ♈ on the 21st of March, he will then rise or make his first appearance to the inhabitants, if any, at the North Pole; and will be seen skimming round the edge of the horizon without setting. As he proceeds in his course through the signs Aries ♈, Taurus ♉, and Gemini ♊, his altitude will gradually increase, until he arrives at the first point of Cancer ♋ on the 21st of June, when he will make his nearest approach to the North Pole; his altitude will then be 23½ degrees. After this he will decline towards the south, decreasing his altitude gradually as he passes through the signs Cancer ♋, Leo ♌, and Virgo ♍, until he arrives at the first point of Libra ♎ on the 23d of September, when he will again be seen skimming round the edge of the horizon, and in a few days will totally disappear; after having been visible* for half a year. Though the Sun will set about the 23d of September, yet whilst he passes through the sign Libra ♎, and about two-thirds of Scorpio ♏, viz. till about the 12th of November, they will have constant twilight.

From the 12th of November till about the end of January, that is, whilst the Sun passes through the signs Sagittarius ♐, (Plate II.) Capricornus ♑, and about one-third of Aquarius ♒, the inhabitants of the North Pole will be entirely deprived of the light and genial influence of that luminary; but the Stars will be visible and continue to shine most brilliantly during that period. Though the Stars in the northern hemisphere will continue above the horizon, yet they will be rendered invisible, on account of the superior splendour of the Sun, all the rest of the year.

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* The refraction of the atmosphere, which causes the Sun to appear above the horizon of the Poles a fortnight before the time here given, and prolongs his appearance above it for the same length of time, is not noticed in this and the following problems.

While the Sun passes through the remaining part of Aquarius ♒ and Pisces ♓, until he arrives again at the first point of Aries ♈, that is, from the end of January till the 21st of March, they will have their morning twilight. After which the Sun will rise, and repeat the phenomena.

Of the Moon and Planets.

The Moon revolves round the Earth, reckoning from one new moon to another, in 29½ days; and as she proceeds on her journey, describes a circle in the Heavens, which is in or very near the ecliptic. The Moon, therefore, being above the horizon whilst proceeding on her course through that half of the circle which is north of the equinoctial, will be visible to the inhabitants of the North Pole for a fortnight without setting; and whilst she is going through that half of the circle which is south of the equinoctial, will be below the horizon; consequently, she will be invisible for the same length of time.

The Moon is always full when in that sign which is diametrically opposite to the Sun; therefore, every full moon will be visible at the North Pole, as long as the Sun is passing through the winter or southern signs: viz. from the 23d of September to the 21st of March.

Whilst the Sun is passing through Libra ♎, Scorpio ♏, and Sagittarius ♐, that is, from the 23d of September till the middle of December, the Moon will be full in Aries ♈, Taurus ♉, and Gemini ♊, and will continue visible during a part of the second, the whole of the third, and part of the fourth quarters. But, when the Sun enters Capricornus ♑ on the 21st of December, being then at his greatest depression below the horizon, the Moon will be full in Cancer ♋, or at her greatest elevation above the horizon; and will continue visible during the whole of the second and third quarters. As the Sun proceeds through Capricornus ♑, Aquarius ♒, and Pisces ♓, the Moon will be visible during a part of the first, the whole of the second, and a part of the third quarters. Thus the inhabitants of the North Pole are supplied with constant Moon-light every alternate fortnight, during their dreary six months night; being invisible in her first and last quarters only, when she affords but little light, consequently, would then be of little benefit to them.

These phenomena may be rendered perfectly easy to be understood, by tracing the courses of both luminaries through the several signs; the North Pole of both hemispheres being still elevated 90 degrees above the horizon.

The Planets also, as seen from the Earth, appear to move through the Heavens in circles, which are in, or very near the ecliptic; therefore, those which may happen to be in the signs which are north of the equinoctial, will continue visible at the North Pole during the winter months. Of these, Jupiter and Venus will be the most conspicuous.

PROBLEM II.

TO ILLUSTRATE THE PHENOMENA OF THE HEAVENLY BODIES AS SEEN AT THE EQUATOR.

Of the Fixed Stars.

The inhabitants who live upon the Equator, have the Celestial Poles in the horizon, and the Equinoctial over their heads. Therefore, place the Poles of the Hemispheres (Plate I. and II.) in the horizon; then will the Equinoctial be perpendicular thereto; consequently will cut it at right angles.* And, as the Polar Circles, the Tropics, and all the circles of daily motion are parallel to the Equinoctial, they will be perpendicular to, or at right angles with the horizon also; hence the apparent diurnal motion of all the Celestial Objects will be in circles cutting the horizon at right angles. The inhabitants of the Equator are, for this reason, said to have a right sphere.

* A Right Angle is that which is formed by one line perpendicular to another, and contains 90 degrees, or a quarter of a circle.

The Equinoctial, Tropics, Polar Circles, and all the circles in which the Heavenly Bodies move, will be divided by the horizon into two equal parts; one of which will always be above, and the other below it. Therefore the Stars will ascend from the east perpendicularly above the horizon for six hours, and after passing the Meridian, they will descend in like manner towards the west for the succeeding six; then set, and continue below the horizon for the remaining twelve hours.

For instance, if the Star Alpheratz, in the head of Andromeda, (Plate I.) rises at six in the evening, it will move in a circle a little north of the Tropic of Cancer, come to the Meridian at midnight, and set at six in the morning. It will also appear evident, from an inspection of this Plate, that if Alpheratz appears in the eastern horizon at six in the evening, all the Stars in the upper part of the hemisphere, that is, half the Heavens from pole to pole, will be visible to *a*, an inhabitant of the Equator; but in twelve hours after, that is, at six in the morning, they will be carried, by the apparent diurnal motion of the Heavens, below the western horizon; and the Stars in the lower part will be brought round to supply their places: consequently, the whole of the Starry Heavens will be visible to the inhabitants who live upon the Equator, in the course of twenty-four hours.

The Stars which are situated in or near the Equinoctial, as the three in the belt of Orion, will pass over *a* the observer's head, making the largest circle; whilst those which are remote from it, will pass the Meridian either to the north or south of him, according as the Stars are situated in the northern or southern hemisphere, describing smaller circles proportionally as their declination from the Equinoctial increases. Thus, Alpheratz in the head of Andromeda, and the three Stars in the head of Cepheus, will pass the Meridian to the north of the observer; and the latter will describe a smaller circle than the former, because they are more remote from the Equinoctial: but the time between the rising and setting of all the Stars will be equal.

Of the Sun, Moon, and Planets.

The diurnal motion of the Sun is either in the Equinoctial or in circles nearly parallel to it. His apparent daily motion round the Earth will be in the Equinoctial only, when he enters the first degree of Aries ♈ and Libra ♎, which takes place about the 21st of March and the 23d of September: the former being called the Vernal, and the latter the Autumnal Equinox. The Sun will then rise due east, appear in the zenith at noon, and set due west; but on every other day he will rise and set to the north or south of those points, apparently revolving in circles nearly parallel to the Equinoctial.

For as the Sun passes through the signs Aries ♈, Taurus ♉, and Gemini ♊, (Plate I.) he apparently moves round the Earth in circles, which gradually decline to the north of the Equinoctial as he proceeds in his path through these signs. When he arrives at the first degree of Cancer ♋, (Plate II.) on the 21st of June, being then in his utmost northern limits, he passes vertically over all the inhabitants, who live on the Tropic of Cancer.

As the Sun proceeds in his annual course through the descending signs Cancer ♋, Leo ♌, and Virgo ♍, (Plate II.) he comes to the Autumnal Equinox on the 23d of September, passing vertically over the equatorial inhabitants. After which, as he passes through Libra ♎, Scorpio ♏, and Sagittarius ♐, he gradually declines to the south of the Equinoctial, till he enters the first degree of Capricornus ♑, (Plate I.) on the 21st of December, when he reaches his utmost southern limits, passing vertically over the inhabitants who live on the Tropic of Capricorn.

Therefore, the inhabitants of the Equator see the Sun to the north of them during one half of the year, and to the south of them during the other half. The Sun rises at six in the morning, and sets at six in the evening throughout the year, because his diurnal path is divided into two equal parts by the horizon; hence their days and nights are always twelve hours long.

The Moon will appear on the north and south of the observer every alternate fortnight; but the Planets will vary their position, with respect to the observer, at unequal intervals of time. Mercury will follow close after the Sun; Venus's changes will be the most frequent; Mars will continue on the north or south for more or less than a year; and Jupiter, Saturn, and Herschel, for a much longer period, according to their respective distances from the Sun: but all of them will rise and set perpendicular to, and continue as long above as below the horizon.

PROBLEM III.

TO ILLUSTRATE THE PHENOMENA OF THE HEAVENS AS SEEN BETWEEN THE EQUATOR AND THE POLES.

In every other position of the observer than those already described in the first and second problems, the Equinoctial and all the circles of daily motion will form an oblique angle* with the horizon; consequently, all the inhabitants of the Earth who live between the Equator and the Poles, will have an oblique sphere.

The angle which the Equinoctial makes with the horizon will be equal to the complement† of the latitude of the place of observation; therefore, to an observer at Petersburgh in latitude 60 degrees north, the angle formed between the Equinoctial and the horizon will be 30 degrees; at London in latitude 51½ degrees north, the angle between them will be 38½ degrees; and at Madrid in latitude 41 degrees north, the angle will be 49 degrees. This will appear evident by elevating the North Pole (Plate I.) as many degrees above the north point of the horizon N, as are equal to the latitudes of these places; for the number of degrees contained between o on the Brass Meridian and the south point of the horizon will be equal to the above angles.

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* An oblique angle is either greater or less than a right angle.

† The complement of the latitude, or of an angle, is what it wants of 90 degrees.

In an oblique sphere, the horizon will divide the Equinoctial only, into two *equal parts;* whilst all the circles parallel to it will be divided into two *unequal parts.* That part which is above the horizon, is called the *diurnal,* and that which is below it, the *nocturnal arc.* To the inhabitants of the northern hemisphere, the *diurnal* will exceed the *nocturnal arcs,* from the Equinoctial towards the North Pole; and the *nocturnal* will exceed the *diurnal arcs,* from the Equinoctial towards the South Pole. The reverse of this will be observed by the inhabitants of the southern hemisphere.

To rectify the Globe so as to represent the general appearance of the Heavenly Bodies as seen at any particular place, the pole must be elevated as many degrees above the horizon, as are equal to the latitude of that place. If the place be in north latitude, the North Pole must be elevated above the north point of the horizon; and if it be in south latitude, the South Pole must be elevated above the south point of the horizon.

By elevating the North Pole (PLATES I. and II.) for the latitude of London, that is, 51½ degrees above the north point of the horizon N, it will be plainly seen that, the following phenomena may be observed by the inhabitants of that metropolis.

Of the Fixed Stars.

The student in contemplating the Stars on a clear evening, will observe continual changes in their positions with respect to the horizon. Fresh Stars will be seen rising in the east, whilst others are setting in the west. If he turns his attention towards the southern half of the visible heavens, he will find the Stars revolving from east to west, and making arcs which are inclined to the horizon in an angle of about 38½ degrees.

Those which rise due east, will continue above the horizon for twelve hours; whilst those which rise on the south of the east point, will make smaller arcs, and set sooner in proportion, as the rising point approaches the south; those which rise north of the east will make larger arcs, and take a longer time before they set.

If the student turns his face towards the northern half of the Heavens, he will find that those Stars which appear in the north point of the horizon, will ascend towards the east until they reach the zenith, or the point over his head; then descend towards the west, until they come round to the place from whence they set out. Others that appear more elevated in the north, will be found to describe similar circles, which will diminish as their elevation above the horizon increases, till at last he will come to a Star of the second magnitude, which will appear to be motionless, but round which, as a centre, all the Stars seem to turn. This Star is called the North Pole Star, which may be easily found at any time of the night, by means of two others situate in the body of Ursa Major, named Dubhe and Merak. These are generally termed the Pointers, as an imaginary line passing through them, directs the eye to the Pole Star.

Let us suppose the hemisphere (PLATE I.) to revolve on its axis, it will then be easy to conceive that Fomalhant, the principal Star in Pisces Australis would rise very near the south, describe a small arc, and very soon go down; whilst the Pleiades would rise between the north and east, describe a very large arc, and continue a long time above the horizon. Vega, a Star of the first magnitude in Lyra, would just graze the north point of the horizon, then mount up the Heavens, pass the meridian about 13 degrees south of the zenith, and describe a complete circle without setting. All those Stars which are north of the dotted circle, called the circle of *perpetual apparition*, revolve about the pole without descending below the horizon; the most conspicuous of which, are the seven principal Stars in Ursa Major, (PLATE II.) commonly known by the names of Charles's Wain, the Plough and Horses, &c. The motion of which may easily be detected by observing their position at different hours of the night.

There is another dotted circle at the same distance from the South Pole, as the other is from the North, that is 51½ degrees; this is called the circle of *perpetual occultation.* All the Stars within it, never appear above the horizon, consequently, they are invisible to the inhabitants of London.

Of the Sun.

The distance of the Fixed Stars from the Equinoctial always continues the same; at least, the variation in their declination is not perceptible to common observation for a great number of years; therefore, they will always appear to rise and set in the same point of the horizon. But the Sun, in performing his apparent annual journey through the Ecliptic, changes his position daily; rising every morning farther to the north or south, and appearing more or less elevated at mid-day than he did on the day preceding: for it is well known to almost every one, that the Sun is not so high at noon in winter, as he is in summer.

If we begin our observations on the shortest day, the 21st of December, when his diurnal path is in the Tropic of Capricorn, we shall perceive him rising in the south-east, making a small arc, and setting in the south-west, after having been above the horizon about eight hours. His meridian altitude or height at noon, at this time of the year, will be only 15 degrees; as may be seen by counting the degrees contained between the Tropic of Capricorn and the south point of the horizon: the pole being elevated as before.

From the 21st of December to the 21st of June, the Sun will be observed to rise more to the north, mount higher in the Heavens, and continue longer above the horizon; for as he passes through the ascending signs, viz. from Capricornus ♑, through Aries ♈, to Cancer ♋, the *diurnal arcs* will increase, and the *nocturnal arcs* decrease; consequently, the days will lengthen and the nights shorten. When the Sun arrives at the Tropic of Cancer on the 21st of June, we have our *longest day* and *shortest night.* By counting the degrees contained between that circle and the south point of the horizon, it will be found that his meridian altitude will be about 62 degrees. It will also appear, from an inspection of the Plate, that the Tropic of Cancer is about two-thirds above the horizon; hence the length of our longest day will be about sixteen hours. And as the twilight continues until the Sun is 18 degrees below the horizon, it will be *twilight all night;* because the Sun, being then in the first degree of Cancer, will not descend more than 15 degrees below the north point of the horizon.

The Sun having now attained his greatest height in the Heavens, begins to descend towards the south, and continues his retrograde motion as he passes through the signs Cancer ♋, Leo ♌, Virgo ♍, Libra ♎, Scorpio ♏, and Sagittarius ♐; the days getting shorter and the nights longer, until he enters the first degree of Capricornus ♑, on the 21st of December; when he again remounts and renews the phenomena.

If we trace the apparent annual course of the Sun through all the signs of the Zodiac, in the order above mentioned, we shall find that he crosses the Equinoctial in two opposite points, namely, Aries and Libra; the former takes place on the 21st of March, and the latter on the 23d of September; when his diurnal path will be in the Equinoctial, which is equally divided by the horizon: consequently, we then have *equal day and night.* The days will be longer than the nights as long as the Sun is in the northern signs; and the reverse when he is in the southern signs.

Of the Moon.

The motion of the Moon through the Heavens, and the various forms she exhibits at different times; together with the utility of the light she affords us in the absence of the Sun, are sufficient to excite the attention and to gain the admiration of every young student in Astronomy.

When she first becomes visible, about three or four days after the change, she is called the New Moon, and may be seen in the western part of the Heavens in the form of a beautiful crescent; but being at a short distance from the Sun, she will set very early in the evening. Every night she will not only appear more enlightened, but at a greater distance from the Sun, till at last she will appear in the eastern part of the horizon, with a full face when the Sun is disappearing in the western. She will then gradually move farther from the Sun, rising later and later every night, till at last she will seem to approach him as nearly in the eastern part of the Heavens as she did before in the western; and will rise a short time before him in the morning, as in the first part of her course, she set in the west not long after him. All these different appearances are completed in 29 days and a half, after which they are repeated in the same order as before.

It has already been observed in Problem I. that the apparent motion of the Moon is in, or very near the Ecliptic: hence she will rise from different parts of the horizon, similar to the Sun, and will be more or less elevated when on the Meridian, according to the sign through which she is passing. For, when in Cancer ♋, she will rise in the north-east, and pass the Meridian not far from the zenith; but when in Capricornus ♑, she will rise in the south-east, and ascend only a few degrees above the horizon. The greatest elevation she can possibly attain is about 67 degrees, and the least about 10 degrees.

Our winter Full Moons are more elevated and continue longer above the horizon, than the Full Moons do in summer; for, the Moon when full is always in that sign which is opposite to the Sun; and, as the Sun is in the southern signs during our winter months, the Full Moons will be in the northern signs at the same time, and *vice versa:* consequently, the Full Moons in winter will be more elevated than those in summer.

The Sun being in Capricornus ♑, or the lowest point of the Ecliptic on the shortest day, the Full Moon will then be in Cancer ♋, or the highest point; therefore she will be *most* elevated and continue *longest* above the horizon at that season of the year, when her light is *most* wanted. The inhabitants of the southern hemisphere also, enjoy a similar benefit during their winter season.

Of the Planets.

Only four of the Planets are visible to the naked eye, namely, Venus, Mars, Jupiter, and Saturn; the apparent paths of which are in the Zodiac: therefore, when they are in the northern signs, their meridian altitude will be greatest, and least when they are in the southern signs. They may generally be seen, if the sky be clear, either in the evening or the morning; except when they are so near the Sun as to be lost in the superior splendour of his rays.

PROBLEM IV.

THE LATITUDE OF A PLACE GIVEN, TO FIND THE CONSTELLATIONS WHICH NEVER RISE, AND THOSE WHICH NEVER SET TO ITS INHABITANTS.

ELEVATE the north or south pole of both Hemispheres above the corresponding point of the horizon, according to the name of, and as many degrees as are equal to the latitude of the place; draw a curved line from the north and south points of the horizon parallel to the Tropics or Polar Circles; then, that curved line which is above the horizon, will be the *circle of perpetual apparition*,* and that which is below it, the *circle of perpetual occultation:* all the Constellations included by the former circle will never set, and all those included by the latter will never rise, to the inhabitants of the place.

EXAMPLES.—Required the names of those Constellations which never rise, and of those which never set at Petersburgh?

The latitude of Petersburgh is 60° N, therefore, elevate the north pole of both hemispheres 60 degrees above the north point of the horizon; draw the *circle of perpetual apparition*, from the north point of the horizon parallel to the Tropic of Cancer, and the *circle of perpetual occultation*, from the south point of the horizon parallel to the Tropic of Capricorn; then, the Constellations which are included by the former circle will never set, and those included by the latter, will never rise to the inhabitants of Petersburgh. The Constellations which never set, are

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* See the definitions, page 45.

Auriga, Perseus, Andromeda, Cassiopeia, Tarandus, Camelopardalis, Lacerta, Cepheus, Cygnus, and Lyra, (Plate I.) the feet of Hercules, Corona Borealis, and the head of Bootes, Canes Venatici, Leo Minor, Lynx, Ursa Major, Draco, and Ursa Minor, (Plate II.) Those which never rise are Sagittarius, Corona Australis, Microscopium, Pisces Australis, Apparatus Sculptoris, Fornax Chemica, Columba Noachi, Cela Sculptoria, Equuleus Pictoris, Dorado, Horologium, Reticulus, Hydrus, Phœnix, Touchan, Octans, Indus, Pavo, Grus, and Telescopium, (Plate I.) Argo Navis, Antlia Pneumatica, Centaurus, Lupus, the tail of Scorpio, Norma, Ara, Triangulum Australis, Circinus, Apus, Crux, Robur Coroli, Pisces Volans, and the Chameleon, (Plate II.)

Required the names of those Constellations which never rise, and of those which never set at Rio Janeiro, in latitude 23° s.?

Elevate the south pole of both Hemispheres 23 degrees above the south point of the horizon; then, the *circle of perpetual apparition* will be found to coincide nearly with the Antarctic Circle, and the *circle of perpetual occultation* as near to the Arctic Circle; therefore, all the Constellations enclosed by the former will never set, and those which are enclosed by the latter, will never rise to the inhabitants of Rio Janeiro.

PROBLEM V.

TO FIND THE SUN'S PLACE IN THE ECLIPTIC, AND HIS DECLINATION.

Look for the given day on the right hand page of the month in White's Ephemeris, against which, in the adjoining column, will be found the sign and degree in which the Sun is for that day. Find the same sign in the Ecliptic, (Plate I. or II.) from which set off the degrees of that sign, taken with a pair of compasses from the scale of degrees, (Plate II.) then lay the edge of a thin strip of whalebone over the Sun's place, and parallel to the Equinoctial or Tropics; and the number of degrees on the Brass Meridian contained between the edge of the whalebone and the Equinoctial, will be the Sun's declination for that day.

Examples.—Let it be required to find the Sun's place and declination for the 1st of June, 1830?

Opposite the day of the month in the Ephemeris stands ♊ 10° 25′ 14″, or nearly 10½ degrees of Gemini. Take 10½ degrees in the compasses from the scale of degrees, and set it off from Gemini ♊ towards Cancer ♋, (Plate I.) and where the point falls will be the Sun's place. Then, laying the whalebone over the Sun's place, and parallel to the Tropic of Cancer, its edge will cut the Brass Meridian at the 22d degree north of the Equinoctial; consequently, the Sun's declination will be 22° N.

Required the Sun's place and declination for the 21st of June, 7th of September, 2d of November, and the 10th of March?

PROBLEM VI.

TO FIND THE SUN'S MERIDIAN ALTITUDE FOR ANY GIVEN DAY AND PLACE.

Find the Sun's declination by Problem V., and elevate the north pole as many degrees above the north point of the horizon, as are equal to the latitude of the place. Then, the number of degrees on the Brass Meridian, contained between the Sun's declination and the south point of the horizon, will be his Meridian Altitude for that day. If the place be in the southern hemisphere, read south for north, and north for south.

Examples.—Required the Sun's Meridian Altitude at London on the 1st of June?

Elevate the north pole, (Plate I.) 51½ degrees above the horizon, then, by Problem V., it appears that the Sun's declination will be 22° N; the number of degrees contained between the declination and the south point of the horizon 60°$\frac{1}{2}$: therefore, the Sun's Meridian Altitude will be 60$\frac{1}{2}$ degrees on the given day.

Find the Sun's Meridian Altitude on the 21st of March, the 21st of June, and the 23d of September, at Petersburgh in latitude 60° N; Madras 13° N; Rio Janeiro 23° S; and at Cape Horn in latitude 56° S.?

PROBLEM VII.

TO FIND THE LATITUDE OF A STAR.

The parallels of latitude are drawn to every tenth degree of latitude, therefore, if a Star be on any parallel, multiply the number of parallels between the Ecliptic and the Star by 10; and if it be between two, the degrees may be estimated sufficiently near by the eye.

Examples. Required the Latitude of Sirius in Canis Major, and of Procyon in Canis Minor (Plate I.)?

Sirius is on the third parallel, therefore its Latitude is 30° S; and as Procyon is rather nearer to the second than the first parallel, its latitude may be estimated at 26° S.

Required the Latitudes of the following Stars, viz. Betelguex in the right shoulder and Rigel in the left foot of Orion, Aldebaran in Taurus, Vega in Lyra, (Plate I.) Castor in Gemini, Arcturus in Bootes, and Antares in Scorpio (Plate II.)?

PROBLEM VIII.

TO FIND THE LONGITUDE OF A STAR.

The Longitude of a Celestial Object is reckoned on the Ecliptic, in signs and degrees, eastward from the first point of Aries ♈; therefore, to find the Longitude of a Star by these plates, it must be traced to the Ecliptic; if it be on a Circle of Longitude, trace it on that circle, but if it be between two circles, it must be traced at a proportional distance from each, till the tracer comes to the Ecliptic. Then, set one foot of a pair of compasses on that point and extend the other to the nearest sign on the left of it; apply the compasses to the scale of degrees, (Plate II.) and it will give the Longitude of the Star in degrees of that sign.

Examples. What is the Longitude of Pollux in Gemini, and Dubhe in Ursa Major?

The Longitude of Pollux will be found to be in ♋ 21°, and that of Dubhe in ♌ 12°.

Required the Longitude of Capella in Auriga, Algol in Perseus, Mencar in Cetus, Bellatrix in Orion, (Plate I.) Antares in Scorpio, Cor Hydra in Hydra, and Regulus in Leo Major (Plate II.)?

PROBLEM IX.

THE LATITUDE AND LONGITUDE OF A STAR GIVEN, TO FIND IT ON THE GLOBE.

Look for the Sign of the Longitude on the Ecliptic, and set off, on the right hand of it, the degrees taken with the compasses from the scale; then trace north or south, according to the name of the latitude, keeping at a proportional distance from the nearest circle of longitude, till you come to the given latitude, where you will find the Star required.

Examples.—Required the name of that Star, which is in latitude 62° N. and longitude ♑ 12°.?

Look for the sign ♑ on the Ecliptic, (Plate I.) and set off 12 degrees on the right hand of it; then, tracing north till you come to the latitude of 62° N. you will find the Star to be Vega in Lyra.

What Stars have the following latitudes and longitudes?

Latitudes.	*Longitudes.*	*Stars required.*	*Latitudes.*	*Longitudes.*	*Stars required.*
16° S.	♊ 26°	Betelguex in Orion.	0°½ N.	♌ 27°	
10° N.	♋ 17°	Castor in Gemini.	12° N.	♍ 19°	
23° N.	♊ 19°	Capella in Auriga.	2° S.	♎ 21°	
5° S.	♊ 7°	Aldebaran in Taurus.	31° N.	♎ 22°	

PROBLEM X.

THE LATITUDE AND LONGITUDE OF THE MOON OR A PLANET GIVEN, TO FIND ITS PLACE ON THE GLOBE.

Set the longitude off as directed in Problem IX., then take the degrees of latitude from the scale with a pair of compasses, and set them off from the longitude to the north or south, according to the name of the latitude, and the point where the foot of the compasses fall, will be the place of the Moon or Planet required.

Examples.—On the 25th of April, 1830, at 8 o'Clock in the evening, the Moon's longitude* will be about ♊ 15° and her latitude 5° S.

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* The Longitude of the Moon and Planets is given for every day at noon in White's Ephemeris, and may be reduced to any given hour by proportion; for as 24 hours is to the difference in 24 hours, so is the given time past noon to the difference in that time; which, added to the Longitude at noon, will give the Longitude for the hour. The Latitude taken out for the nearest noon, will be sufficiently exact.

Take 15 degrees from the scale with the compasses, and set them off to the right hand of Gemini ♊: then, take 5 degrees and set them off from the 15° of ♊ towards the south pole of the Ecliptic, and the Moon's place for the given day and hour will be found to be near the southern horn of Taurus. She will then be about three days old, and may be seen in the western part of the Heavens about 8 degrees above Aldebaran, a Star of the first magnitude in Taurus, of a dusky red appearance.

Find the place of the Moon on the Globe for the following days, at 9 o'Clock each evening ?

Given days.	*Latitudes.*	*Longitudes.*	*The Moon's place on the Globe.*
May 28, 1830	1°½ s.	♍ 1°	About 4 degrees south-east of Regulus.
July 5	4°½ N.	♑ 10°	Between the head of Sagittarius and Scutum Sobeiski.
October 21	5° N.	♐ 23°	
December 26	5° s.	♉ 27°	

On the 7th of September, 1830, the Latitudes and Longitudes of the Planets will be as follow: find their places on the Globe.

Planets.	*Characters.*	*Latitudes.*	*Longitudes.*	*Their places on the Globe.*
Venus	♀	0°¾ N.	♌ 18°	Just above the right paw of Leo Major.
Mars	♂	5°¾ s.	♓ 29°	Near the centre of PLATE I.
Jupiter	♃	0°¼ s.	♑ 8°	
Saturn	♄	1° N.	♌ 24°	

It appears from the position of the Planets on the above day, that Jupiter will be on the Meridian about half past seven o'clock in the evening, and at the same time Mars will be rising in the east. The next morning at half past four o'clock, Venus and Saturn may be seen together in the east, forming a direct line with Regulus, the principal Star in Leo Major. Saturn will occupy the middle space; Venus will be about 6 degrees above Saturn, and Regulus only 3 degrees below him.

PROBLEM XI.

TO DESCRIBE THE APPARENT PATH OF THE MOON OR A PLANET, AND TO FIND WHAT STARS THEY WILL MAKE A NEAR APPROACH TO.

Take out the Latitude and Longitude of the Moon from White's Ephemeris for several days, with which find her several positions on the Globe, by Problem X.; draw a line through each of these places, and it will represent the Moon's path for that time. The paths of the Planets may be described in a similar manner, by taking out their Latitudes and Longitudes for every week or month.

Examples.—Represent the apparent path of the Moon on the Globe, and name the Stars she will make a near approach to, from the 19th to the 27th of September, 1830?

The Moon's Latitudes and Longitudes, with the names of the Stars that lie in or near her path are as follow:

Given Days.	*Latitudes.*	*Longitudes.*	*Stars that lie in or near her path.*
Sept. 19, 1830.	4° N.	♎ 27°	Passes 6° N. of Spica Virginis.
—— 21, ——	5° N.	♏ 20°	Passes 5° N. of the principal Star in the south scale of Libra.
—— 23, ——	5°¼ N.	♐ 14°	Passes 9° N. of Antares in Scorpio.
—— 25, ——	4°¾ N.	♑ 9°	Passes 10° N. of the principal Star in the bow of Sagittarius.
—— 27, ——	3° N.	♒ 5°	Passes near two Stars in the head of Capricornus.

What Stars will Venus pass, from the 7th of July to the 13th of September, 1830?

Given Days.	*Latitudes.*	*Longitudes.*	*Stars she will pass.*
July 7, 1830.	2° S.	♊ 5°	About 6 degrees north of Aldebaran.
Aug. 7, ——	0°¾ S.	♋ 11°	Near a Star in the knee of Pollux.
—— 25, ——	0	♌ 2°	Near the principal Star in Cancer.
Sept. 13, ——	1° N.	♌ 26°	Near Regulus in Leo Major.

Delineate the apparent path of Mars, and name the Stars he will pass, from the 1st of January till the 1st of August, 1830?

His Latitude and Longitude for the first day of each month, will be as follows:

Given Days.	*Latitudes.*	*Longitudes.*	*Stars he will pass.*
Jan. 1, 1830.	0°½ N.	♏ 23°	
Feb. 1, ——	0°¼ N.	♐ 14°	
March 1, ——	0°¼ S.	♑ 2°½	
April 1, ——	1° S.	♑ 23°	
May 1, ——	1°½ S.	♒ 13°	
June 1, ——	2°½ S.	♓ 2°¼	
July 1, ——	3°¾ S.	♓ 18°½	
August 1, ——	5° S.	♈ 0°	

PROBLEM XII.

TO ASCERTAIN WHEN THERE WILL BE AN ECLIPSE OF THE SUN.

An Eclipse of the Sun happens at the change of the Moon; therefore, find the Sun's Longitude and the place of the Moon's Nodes,* in White's

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* The Moon's path crosses the Ecliptic in two opposite points: that in which she ascends towards the north, is called the Ascending Node, and is denoted by the Dragon's Head ☊; the other, where she descends towards the south, is denominated the Descending Node, and is represented by the Dragon's Tail ☋.

Ephemeris, at the time of every New Moon; and mark their places on the Ecliptic. If the distance between the Sun's Longitude and the place of the nearest Node be less than 17 degrees, an Eclipse will occur.

Examples.—How many Solar Eclipses will there be in 1830?

Times of New Moon.				*Sun's Longitude.*			*Places of the Moon's Nodes.*				*Distance from nearest Node.*				*No. of Eclipses.*
Month.	*Days.*	*hrs.*	*min.*	*s.*	°	′	☊	°	′	☋		*s.*	°	′	
January,	24	4	54	♒	4	5	♍	21	44	♓	☋	1	17	39	
February,	22	16	36	♓	4	26	–	20	5	–		0	15	39	Eclipse.
March,	24	2	44	♈	3	22	–	18	36	–		0	14	46	Eclipse.
April,	22	11	27	♉	1	50	–	16	68	–		1	14	52	
May,	21	19	13	♊	0	50	–	15	22	–		2	15	28	
June,	20	3	3	♊	28	34	–	13	44	–	☊	2	15	10	
July,	19	12	14	♋	26	14	–	12	8	–		1	15	54	
August,	17	23	53	♌	24	58	–	10	30	–		0	15	32	Eclipse.
September,	16	14	28	♍	24	3	–	8	51	–		0	15	12	Eclipse.
October,	16	7	31	♎	22	37	–	7	16	–		1	15	21	
November,	15	1	55	♏	22	39	–	5	58	–		2	16	41	
December,	14	20	19	♐	23	4	–	4	2	–	☋	2	10	58	

The Sun's Longitude and the place of the Moon's Nodes, being marked on the Ecliptic at the time of every New Moon; the distance between the Sun's place and that of the nearest Node, will be found to be as set down in the fourth column of the above table. By looking over these distances, it will be found, that there are four less than 17 degrees; consequently, there will be four Eclipses, which will happen at the following times:

No.	*Astronomical time.*				*Civil time.*
	Month.	*Days.*	*hrs.*	*min.*	
1	February,	22	16	36	At 36 min. after 4 on the morning of the 23d.
2	March,	24	2	44	At 44 min. after 2 in the afternoon.
3	August,	17	23	53	At 7 min. before 12 on the 18th.
4	September,	16	14	28	At 28 min. after 2 on the morning of the 17th.

The first and fourth will be invisible in consequence of their taking place before the Sun rises: the second and third will be invisible because the Moon's shadow will not extend so far north as the latitude of London.

PROBLEM XIII.

TO ASCERTAIN WHEN THERE WILL BE AN ECLIPSE OF THE MOON.

Lunar Eclipses happen at the time of Full Moon, therefore, find the Longitude and places of her Nodes at the time of every Full, and mark them on the Ecliptic. If the distance between the Moon's Longitude and the place of the nearest Node be less than 12 degrees, there will be an eclipse at that time.

Examples.—The number of Lunar Eclipses and the time they will occur in 1830, is required?

Times of Full Moon.				*Moon's Longitude.*			*Place of the Moon's Nodes.*				*Distance from nearest Node.*				*No. of Eclipses.*
Month.	*Days.*	*hrs.*	*min.*	*s.*	°	′		°	′			*s.*	°	′	
January,	8	15	32.	♋	16	30	♍	22	39	♓	☊	2	6	9	
February,	7	7	42	♌	14	37	–	21	2	–		1	6	25	
March,	9	1	31	♍	17	46	–	19	28	–		0	1	42	Eclipse.
April,	7	19	29	♎	20	11		17	53	–		1	2	18	
May,	7	12	2	♏	16	51	–	16	19	–		2	0	32	
June,	6	2	19	♐	14	6	–	14	43	–		2	29	23	
July,	5	14	24	♑	12	8	–	13	11	–	☋	2	1	3	
August,	4	0	57	♒	11	2	–	11	37	–		1	0	35	
September,	2	10	38	♓	10	43	–	10	6	–		0	0	37	Eclipse.
October,	1	19	57	♈	11	9	–	8	30	–		1	2	39	
	31	5	18	♉	4	24	–	6	56	–		1	27	28	
November,	29	15	8	♊	5	27	–	5	27	–		3	0	0	
December,	29	2	2	♋	6	11	–	3	52	–	☊	1	27	41	

By marking the Moon's Longitude and places of her Nodes on the Ecliptic, you will find that the nearest distance between them at the time of each Full Moon, will be as set down in the fourth column of the preceding table; from which it appears there will be two Lunar Eclipses. The first will happen on the 9th of March, about half past one in the afternoon, when she will be below the Horizon; consequently, the Eclipse will be invisible to us. The second will occur on the 2d of September, at about half past ten in the evening, when she will appear eclipsed between the south and south-east part of the Heavens.

THE SOLAR SYSTEM.

Having illustrated, in the preceding problems, the *apparent* diurnal motion of the Heavenly Bodies as seen from different parts of the Earth; it will now be proper to describe the *real* motions of the Earth and Planets about the Sun; and to consider how those motions are affected by a change in the situation of the observer.

To obtain a distinct knowledge of the Solar System, and of the beautiful order and harmony of the motions of the several Planets of which it is composed; it will be necessary to take a view of it, as if seen from different parts of the Universe.

In whatever part of the Universe we may suppose ourselves to be situated, we still imagine ourselves to be in the centre of it; all the Heavenly Bodies appearing to be placed in the concave surface of the surrounding sphere; because, when objects are at such an immense distance from us, as they really are, and would be were we in any other situation than that in which we are now placed; it is, and would be impossible for us to estimate their distance by the eye. For, though the Sun is about 95 millions of miles from the Earth, and the Moon only 240 thousand, yet both Luminaries appear to the eye to be equally distant; the apparent distance of the Heavenly Bodies being a mere optical illusion.

In the first two pages of this work, I have supposed the spectator to be placed in the centre of the system, and have described the phenomena of the Heavens as seen therefrom. I shall now suppose him to be transferred from thence to a considerable distance above the Sun, so as to be in a line perpendicular to the plane of the Earth's orbit.

From this station he will have a complete view of the order, proportional distances, and motions of the several Planets and Satellites composing the system. The Fixed Stars will seem to have the same positions as before; the Sun will appear stationary in the centre, round which the Planets will be seen to move in circles or ellipses of different dimensions, and each completing its circuit in very different times. Those which are nearest to the Sun, he will find to move with the greatest velocity, and those which are more remote from the Sun, he will observe to move slower in proportion as their distances increase. Mercury makes nearly 347 revolutions round the Sun in the time that Herschel makes one.

On examining these primary Planets with attention, he will perceive that the Earth is accompanied by a very small Planet; Jupiter by four; Saturn by seven, with a double luminous ring surrounding him; and Herschel by six. These small bodies are called secondary Planets, Satellites, or Moons, which he will find to circulate about their primaries as their centre, with the same order and regularity, as the primary Planets do about the Sun.

The Comets will be seen approaching to, and receding from, the Sun in very eccentric elliptical orbits, or long narrow ovals; with their luminous trains or tails streaming out in a direction opposite to that of the Sun.

As a view of the Sun and Planets from this station, bearing the title of THE SOLAR SYSTEM, is common to all astronomical works, I shall here instruct the pupil how to draw one; and supply its place with a moveable diagram, PLATE III., consisting of a representation of the Sun and the orbits of Mercury, Venus, the Earth, and Mars, surrounded by the Zodiacal Constellations; the use* of which will afford him amusement as well as instruction.

To delineate the orbits of all the primary planets in proportion to those of Mercury, Venus, and the Earth, in the third Plate, it would require a circle nearly six feet and a half in diameter to represent the orbit of Herschel, therefore, the drawing which I propose the pupil to make must be done on a smaller scale. A piece of Bristol-board about a foot square will be the most convenient size.

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* See the description and use of the third moveable Plate, further on.

Make a point in the middle of the paper to represent the Sun; then take four of the small divisions, from the left hand side of the scale in PLATE III., as a radius, and setting one foot of your compasses on the central point, describe a circle for the orbit of Mercury. With the several distances of seven, ten, fifteen, fifty-two, ninety-five, and one hundred-and-ninety,* as radii, taken from the same scale, describe six more circles concentric with the first, and the orbits of all the Planets will be completed.

The proportional magnitudes of the Planets and their Satellites cannot be correctly drawn on so small a scale, but they are usually represented by small circles, having the side darkened which is farthest from the Sun.

The characters of the Planets, their order from the Sun, and the number of Moons revolving round them, are as follow: viz. ☿, Mercury, ♀ Venus, ⊕ the Earth with one Moon, ♂ Mars, ♃ Jupiter with four Moons, ♄ Saturn with his Ring and seven Moons, and ♅ Herschel with six Moons. These are to be placed upon their respective orbits after the specimen given in Figure 3, PLATE IV., which contains the orbits of all the Planets except the last two.

The Sphere of the Fixed Stars may be represented by a number of small asterisks, placed irregularly round and beyond the orbit of Herschel; but they must be considered as being at an immeasurable distance from the Sun, and from each other also.

This diagram of the Solar System will materially assist the student whilst reading the following account of the several Planets composing it; in the construction of which, he will derive much more information, than he can possibly obtain from the mere inspection of one already executed.

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* These comparative distances are found by multiplying the mean distance of each planet by 10, and dividing the product by 95000000, which is the mean distance of the Earth from the Sun. Thus, the mean distance of Mercury is 37000000; hence 37000000 × 10 = 370000000, and 370000000 ÷ 95000000 = 4 nearly.

⊙ THE SUN.

The Sun is by far the most resplendent orb we behold in the Heavens. He is situated in the common centre of gravity of all the circumvolving Planets, and is the grand source of life, light, heat, and vegetation; the parent of the Seasons, and the primary cause of Day and Night to us, and to all the planetary system. His mean diameter is 886149 miles, so that it would require 1404951 bodies as large as our Earth, to make one equal to his magnitude; and although the Sun appears no bigger in the Heavens than the Moon, yet the former is about 69 millions of times larger* than the latter. This deceptive appearance arises from the great difference in the distances of the two Luminaries; the Sun being 95 millions of miles from the Earth, and the Moon 240 thousand only.

The Moon revolves about the Earth in a circle, the circumference of which is 15079646 miles; now in order to assist the student a little farther in forming an adequate idea of the immense bulk of the Sun, we will suppose a globe to be large enough to fill the space included by the circle thus described by the Moon, even this enormous globe would be 6 times less than the Sun.

It is by his attractive influence, that the Earth and all the Planets are retained in their respective orbits; otherwise they would fly off into boundless space.

The Sun was considered by the ancients to be an immense body of fire; but modern philosophers, especially Dr. Herschel, describe him as being an opaque habitable globe, similar to the Planets, and surrounded by a double set of clouds. The upper stratum of these clouds is supposed to be of a luminous and phosphorous nature, which emits and diffuses light through every part of the Solar System; and there are many facts which shew, that the heat we derive from the Sun, is produced by his rays coming in contact with the calorific matter contained in the Earth. Fire is produced by the collision of a flint and steel, or by rubbing two pieces of wood together; and quicklime when mixed with cold water, becomes hot. Heat is also obtained by the mixture of many chemical fluids.

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* To find how many times one globe is larger than another, divide the cube of the diameter of the greater, by the cube of the diameter of the lesser, and the quotient will shew how many times the former is larger than the latter.

The lower stratum of clouds is supposed to be more dense, and capable of protecting the immediate body of the Sun from the intense heat produced by the combustion of the external phosphorescent clouds; and thereby rendering this magnificent globe a fit residence for animated existence.

But, Dr. Brewster is of opinion that the opaque body of the Sun is not an habitable world; but is the principal cause of the production and preservation of the solar heat; for he says, " If the Sun is an habitable globe, we should expect, at least, that the inhabitants would be rational beings, endowed with intelligence equal (if not superior) to that of man, and availing themselves of their central position, to study the interesting phenomena of the various planets which revolve around them, and of the numerous suns (the fixed stars) which their own globe would seem to resemble. If there is one place in the system more than another where astronomy could be studied with the greatest facility, and carried to the highest perfection, that place would be in the Sun, where, excepting the phenomena arising from its monthly rotation, the *real* and *apparent* motions of the heavenly bodies must be exactly the same. But these results of analogy are mere illusions of the mind; Nature has drawn an impenetrable curtain (the lower stratum of clouds) between the inhabitants of the Sun and the worlds which circulate around them: she has doomed them to the most solitary dwelling in the whole circle of creation, and has marked them as either unfit or unworthy to enjoy the noblest privileges of intelligent beings. The planets and stars are equally invisible from the surface of that luminary, unless when a transient glimpse of the heavens is obtained through an accidental opening in the solar atmosphere. From the year 1676 to the year 1684, there was not a single spot in the Sun's atmosphere; so that, during eight successive years, the inhabitants of that globe, if they do exist never once obtained a glance of that starry firmament, from the contemplation of which a Supreme Being could scarcely have excluded any of his rational creation.

"To maintain, therefore, that the Sun is peopled by intelligent beings, is to reason in defiance of the strongest analogies, and support opinions which posterity will rank among the aberrations of the human mind. Might we not as well suppose, that the central caverns of our own planet, which cosmogonists have filled with fire or with water, are the abode of a rational population, who, like the inhabitants of the Sun, are occasionally permitted to obtain a transient view of the heavens, through the craters of volcanoes, or the chinks and fissures which may accompany the convulsions of the globe."

By the assistance of a telescope, several dark spots may be seen on the surface of the Sun, of various forms and magnitudes; some of which have been found to exceed the Earth in size. They are supposed to be parts of his opaque body which appear through the occasional openings of the luminous clouds.

These spots vary in their positions, continuance, and appearances; some of them are of short duration, and proceed from a cause with which we are yet unacquainted. Dr. Long, whilst examining the Sun's image thrown upon a sheet of white paper, observed a large round spot divide itself into two, which separated with great rapidity. A similar phenomenon was also seen by the Rev. Dr. Wollaston, whilst observing a spot through a twelve-inch reflector. The spot suddenly burst in pieces, in the same manner as ice, which, thrown upon a frozen pond, breaks in pieces, and slides in various directions. Others which are more durable, appear first on the eastern limb of the Sun, and after passing slowly across his disc, disappear on his western limb. When they have been missing about the same length of time as they were visible, they re-appear, as at first, on his eastern edge.

By this periodical motion of the spots across the Sun's disc, from east to west, astronomers have determined that he revolves on his axis from west to east once in 25 days, 14 hours, 8 minutes. The Sun has a motion also round the common centre of gravity of all the Planets, occasioned by their attraction. Besides these *real* motions of the Sun, he has two others, which are termed *apparent ;* the first is performed *yearly* through the several signs of the Zodiac, and the second *daily* round the Earth ; the former is occasioned by the *annual* motion of the Earth, and the latter, by its *diurnal* motion.

The Sun, and all his attendant Planets, are supposed to have a progressive motion towards the Constellation Hercules. This is inferred from the Stars in that part of the Heavens appearing to recede a little from each other; while those in the opposite regions seem to be gradually approaching.

☿ MERCURY.

THE Planet Mercury is the first in order from the Sun, round which he revolves, at the amazing rate of 110 thousand miles per hour;[*] completing his revolution in 87 days, $23\frac{1}{4}$ hours: which is the length of his year. The inhabitants of this planet have, therefore, about four years to our one.

Although Mercury is the nearest planet to the Sun, yet his distance from that luminary is computed to be 37 millions of miles: so that, if a cannon ball were to be projected from the Sun, and continue to fly at the rate of 480 miles per hour, it would occupy nearly nine of our years in travelling thence to Mercury.[†]

The mean diameter of this Planet is 3108 English miles; his mean circumference 9763 miles; and his magnitude about sixteen times less* than that of the Earth.

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[*] The distance of Mercury from the Sun in round numbers, is 37000000 of miles, which is equal to half the diameter of the circle he describes; hence, 37000000 × 2 = 74000000, the whole diameter. Then, as 7 : 22 :: 74000000 : 232571428, the circumference or orbit, which he performs in 87 days, 23 hours, or 2111 hours; therefore, as 2111 hours : 232571428 miles :: 1 hour : 110171 miles, the rate of his travelling per hour.

[†] This is found by the following proportion, viz. As 480 miles : 1 hour :: 37000000 miles : 77083 hours, 20 minutes. Then 77083 hours being reduced, the result will be 8 years, 10 months, 1 week, 2 days, 19 hours, 20 minutes, the time in which a ball would fly from the Sun to Mercury at the above rate. This rule may be applied, for a similar purpose, to all the Planets, by using their respective distances from the Sun as the third term.

The rotation of the Planets on their axes, or the length of their Days and Nights, with the vicissitudes of their Seasons, are determined by the progressive motion of the spots which appear on their respective surfaces.

Mercury is, comparatively, so near the Sun, that he seldom departs more than 28 degrees from him; consequently he is either lost to our view in the dazzling splendour of the Sun, or obscured by the vapours of the horizon: hence astronomers have not had the opportunities of making so many interesting discoveries on this planet as they have had on others.

As no spots have been observed on Mercury's disc, the time of his diurnal motion, the length of his Day, and his Seasons, are not known to us with any degree of certainty; though Schroeter asserts, that he has not only discovered spots, but that he has even measured the height of the mountains on the surface of Mercury, and found the altitude of one of them to be about ten miles. This astronomer is also said to have found the period of Mercury's rotation on his axis to be 24 days, 5 hours, 8 minutes, by observing the variation of some remarkable appearances about his horns. The length of his day according to this account, is nearly equal to 24¼ of ours, but it is exceedingly doubtful.

Mercury emits a bright white twinkling light, and when seen through a telescope magnifying about 200 times, he exhibits phases similar to those of the Moon; for, as his orbit is within that of the Earth, his enlightened disc will be more or less turned from us, in the course of his periodical revolution round the Sun. While he is passing through the superior part of his orbit, or that half which is farthest from the Earth, he appears with more than half his disc enlightened; and with less than half whilst passing through the inferior part or that half which is nearest to the Earth.

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* Globes are in proportion to each other as the cubes of their diameters; hence $7912^3 = 495289174528$ or cube of the Earth's diameter, and $3108^3 = 30022235712$ or cube of Mercury's diameter; then $495289174528 \div 30022235712 = 16$ times Mercury is less than the Earth.

He is never seen quite full, because he is, when in opposition, so near the Sun, as to be lost to our sight in his resplendent beams. The crescented part of Mercury is always turned towards the Sun, which, together with his phases, prove that he is globular, and that he shines only by reflecting the light which he derives from the Sun.

When Mercury passes between the Sun and Earth, his enlightened side is wholly turned from us. In this position he is sometimes seen passing over the Sun's disc in the form of a round black spot. This phenomenon is termed a *transit;* one of which will happen on May 5th, 1832, at noon; and three others as follow, according to the table given by Dr. Brewster, viz. November 7th, 1835, at eight o'clock in the evening; May 8th, 1845, at the same hour; and November 9th, 1848, about half past one o'clock in the afternoon.

The light and heat which this Planet derives from the Sun, are doubtless so qualified by his atmosphere and the matter of which he is composed, as to render him a fit and comfortable abode for rational beings. The Sun appears to the inhabitants of Mercury seven times larger than he does to us, while Venus and the Earth become alternately their morning and evening stars.

♀ VENUS.

The superior brightness and whiteness of Venus, when she appears as an evening star in the western part of the Heavens, seem to attract more of our attention, than any other Planet does in the System. She surpasses even Jupiter in brilliancy, is often seen by the naked eye in open day, and frequently causes objects to cast a sensible shadow in the absence of the Moon.

Venus is the second Planet from the Sun, round which she performs her annual revolution in 224 days, 16¾ hours; and moves in her orbit at the rate of 80 thousand miles per hour.* Her mean distance from the Sun, in round numbers, is 69 millions of miles; and it would occupy nearly 16½ of our years for a cannon ball to fly from the Sun to her, supposing it to move at the rate of 480 miles per hour.† Her magnitude is nearly the same as that of the Earth, her diameter being 7498 miles.

The orbit of Venus is within that of the Earth, for which reason she never appears on the Meridian at midnight, but is constantly seen near the Sun, from which she never removes to a greater distance than 48 degrees; consequently she rises or sets a few hours only before or after the Sun.

When Venus appears on the west of the Sun, she rises before him in the morning, and is then called a *morning star;* but when she is seen on the east of the Sun, she sets after him in the evening, and is called an *evening star.* She retains each title alternately about 290 days, although her revolution round the Sun is completed in less than 225 days. It will doubtless seem rather inconsistent to the young student, that Venus should continue 65 days longer on the east or west side of the Sun, than it takes her to complete her revolution round him; but the reason will be evident, when he recollects that the Earth is going round the Sun as well as Venus, and that both of them travel the same way; therefore, her *apparent* motion is slower than her *real* motion, which sufficiently accounts for the phenomenon.

The telescopic appearance of Venus is similar to that of Mercury, waxing and waning like the Moon, from the beautiful thin crescent to the enlightened hemisphere. Her illuminated side is constantly turned towards the Sun; hence her horns are directed towards the west when she is a morning star, and towards the east when an evening star; which together fully prove her form to be spherical, and that she derives her light from the Sun.

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* For, 69000000 × 2 = 138000000 the diameter, and, as 7 : 22 :: 138000000 : 433714285 the circumference of Venus's orbit, which she performs in 224 days, 16¾ hours, or 5393 hours nearly; hence, As 5393 hours : 433714285 miles :: 1 hour : 80421 miles, the rate of her travelling per hour.

† As 480 miles : 1 hour :: 69000000 miles : 143750 hours, which is equal to 16 years, 5 months, 5 days, 14 hours, the time in which a cannon ball would fly from the Sun to Venus. See the second note, page 93.

Several spots have been discovered on her disc by Cassini, from the motion of which he determined that the rotation on her axis is performed in 23 hours, 20 minutes. Schroeter also, by a series of observations on the phenomena displayed about her horns, found that she revolves on her axis in about 23 hours, 21 minutes: hence we may conclude that the length of her day is about 40 minutes shorter than ours.

The inclination of her axis to the plane of her orbit, is generally supposed to be 75 degrees, that of the Earth is only $23\frac{1}{}$ degrees; consequently the variation in her seasons is proportionally greater than ours. To her equatorial inhabitants, the days and nights are always of equal length, and the four seasons occur twice every year. Those inhabitants who live within 15 degrees on either side of the Equator, have 231 artificial days and nights in their year; while those who live at her Poles have only one, as at the Poles of our Earth. The polar inhabitants of Venus, have a Spring and an Autumn, a Summer as long as both, and a Winter equal in length to the other three seasons.

Mercury and the Earth become alternately her morning and evening stars; the Sun appears nearly twice as large, and all the Celestial Bodies seem to turn round a very different axis, than they do to us.

Venus, like Mercury, is sometimes seen passing over the Sun's disc in the form of a round black spot; but the former phenomenon occurs less frequent than the latter. The last two transits of Venus were in the years 1761 and 1769, and only two will happen during the present century, namely, one on the 8th of December, 1874, and the other in 1882, on the 6th of the same month. These phenomena, though rare, are exceedingly useful to astronomers; for, by the last two, they have been enabled to ascertain the real distance of the Sun, and from hence, the distance of all the Planets have been easily calculated by the following unerring rule of Kepler, namely, As the square of the time which the Earth takes to revolve round the Sun, is to the cube of its mean distance from the Sun, so is the square of the time which any other Planet takes to revolve round the Sun, to the cube of its mean distance; the cube root of which will give the distance required.*

⊕ THE EARTH.

Next to Venus is the Earth, or Planet which we inhabit. Its mean distance from the Sun is 95 millions of miles, consequently a cannon ball would require nearly 23 years in travelling thence to the Earth.†

The form of the Earth has been proved (page 52), to be that of an oblate spheroid, or, of a sphere a little flattened at the poles. Its mean diameter, as calculated from the latest admeasurement of a degree of the meridian (page 56), is 7912 miles, its mean circumference 24856 miles, and its magnitude 1404951 times less than the Sun.‡

The Earth moves in its orbit at the rate of 68 thousand miles per hour; § and performs its annual revolution round the Sun, from the Vernal Equinox to the same again, in 365 days, 5 hours, 48 minutes, 48 seconds; but the time it occupies to complete a revolution from any fixed star to the same star again, is 365 days, 6 hours, 9 minutes, 12 seconds: the former is termed a *solar* or *tropical*, and the latter a *sidereal* year. Our year, therefore, is made to consist of 365 days, 6 hours, which is a mean between the solar and sidereal year.

The Earth revolves on its axis once in 24 hours, which produces the succession of *day and night.* By this motion the inhabitants who reside on the Equator, are whirled round at the rate of 1036 miles every hour, those on the parallel of London 644 miles, and those on the parallel of Petersburgh at the rate of 517 miles per hour;[*] besides the 68 thousand miles before mentioned, which is common to every inhabitant of the globe.

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* Thus the square of 365 days is 133225; the cube of 95 millions is 857375; and the square of 225 days is 50625: hence, As 133225 : 857375 :: 50625 : 325799; the cube root of which gives nearly 69 millions of miles, for the mean distance of Venus from the Sun. This calculation may be much abbreviated by the use of logarithms.

† For, As 480 miles : 1 hour :: 95000000 miles : 197916 hours, 40 minutes, which is equal to 22 years, 7 months, 2 weeks, 14 hours, 40 minutes, the exact time.

‡ The cube of the Earth's diameter is 495289174528, and that of the Sun is 695857408225565949; the latter being divided by the former gives 1404951 times the Earth is less than the Sun.

§ The diameter of the Earth's orbit is 190000000 miles, then, As 7 : 22 :: 190000000 : 597142857 miles, the circumference of its orbit, which it completes in 365 days, 6 hours, or 8766 hours: hence, As 8766 hours : 597142857 miles :: 1 hour : 68120 miles the Earth travels per hour.

The diurnal motion of the Earth from west to east in 24 hours, causes an apparent revolution of the Heavenly Bodies from east to west in the same time;[†] as detailed in pages 59—75.

The inclination of the Earth's axis to the plane of the Ecliptic, with the cause of the Seasons, and of the different lengths of our Days and Nights, are fully illustrated in the description and use of the third moveable Plate.

The Earth is surrounded by a thin, transparent, and elastic fluid, called the Atmosphere; which, like all other terrestrial bodies, gravitates towards the Earth's centre, and revolves with it in its annual and diurnal motions.

The Atmosphere is most dense or heavy near the surface of the Earth, but becomes rarer or lighter in proportion to its height; this may be familiarized by supposing a thousand fleeces of wool, of equal size and weight, piled one upon another, when the lowest would be greatly compressed or squeezed together, but the others would be less compressed in proportion to the number of fleeces or weight upon them, till we come to the highest, which would lie in its natural loose state.

It is calculated that a cubic inch of the air we breathe, would be so much rarified or expanded at the height of 42 miles, as to fill a space 4096 times larger than it occupied before.

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[*] These velocities are found by multiplying the number of miles contained in a degree of longitude, in the latitude of the given places, by 15. Thus, the length of a degree on the Equator is 69·07 English miles, in the latitude of London it is 42·95 miles, and in the latitude of Petersburgh 34·5 miles: hence, 69·07 × 15 = 1036·05 miles; 42·95 × 15 = 644·25 miles; and 34·5 × 15 = 517·5 miles.

[†] This, and at page 60, is not strictly true, for the Earth makes a complete revolution on its axis, from the time any meridian passes a fixed star till it returns to the same star again, in 23 hours, 56 minutes, 4 seconds; therefore, the stars will culminate 3 minutes, 56 seconds earlier every day. In consequence of the Ecliptic being inclined to the Equator, together with the unequal motion of the Earth in its orbit, the time of the Sun's being on the meridian differs at different times of the year. See the definition of Equation of time, page 46.

The Moon also souths or arrives at the meridian three-quarters of an hour later, at a mean rate, every day, which is occasioned by her daily motion eastward in her orbit.

In its natural state, it produces wind, rain, snow, thunder, lightning, and a variety of meteors. By the condensation, rarefaction, and exhaustion of the air, many useful and interesting experiments are performed; from some of which it is proved that, without an atmosphere, neither animal nor vegetable could exist, sound could not be produced, nor would there be either rains or dews to moisten the ground.

If we had no atmosphere, only that part of the Heavens in which the Sun is situated, would be enlightened by his rays; and if a person were to turn his back towards the Sun, the sky before him would be dark as night, and the stars would be visible by day as well as by night. But by means of the atmosphere, which reflects light in all directions, the whole Heavens are so strongly illuminated by the resplendent rays of the Sun, as to render the stars invisible.

The rays of light, in passing through mediums of different densities, deviate from a right line towards a curve, with the convex part upwards. The density of the atmosphere varies with its altitude; therefore, the rays of light proceeding from any Celestial Object, are turned out of their rectilineal course, and come to the eye of an observer in a different direction from that of the object, and make it appear higher than its real place.

This difference in the *real* and *apparent* place of the Heavenly Bodies, is termed *refraction;* and must be subtracted from their observed altitudes, to obtain their true altitudes. It is greatest when the object is in the horizon, and gradually diminishes with the increase of its altitude, till it reaches the zenith, where the refraction vanishes.

The refraction of an object, when in the horizon, is about 33 minutes of a degree, and the apparent diameter of the Sun is 32 minutes; therefore, the whole disc of that luminary, at his rising and setting, appears above the horizon when he is actually below it. The difference of time between the real and apparent rising and setting of the Sun, caused by refraction, depends much on the state of the air, sometimes it amounts to five minutes, but the mean rate is about three minutes and a quarter.

The effects of refraction cannot be more familiarly illustrated, than by Ferguson's experiments. First, put a basin where the Sun will shine obliquely upon it, and mark the place where the shadow of the rim falls on the inside; then pour water gently into the basin, and you will observe the shadow to fall towards the bottom; which proves that the Sun's rays, in passing obliquely through the water, are refracted or bent down towards a curve. Secondly, place a shilling at the bottom of the basin, and retire till you just lose sight of it, then, keeping in that position with your eye steadily fixed towards the object, while an assistant fills the basin gently with water, and the shilling will, by the refraction of the water, be fully brought to your sight. In this experiment, the shilling may represent the Sun, the edge of the basin the horizon, and the water the atmosphere.

When the Sun comes within 18 degrees of the eastern horizon, his rays, being refracted, illuminate a great portion of the upper regions of the atmosphere, thence they are reflected to the Earth, and cause a faint light, called *twilight*, which increases till sun-rise; for the same reason we have twilight after sun-set, which decreases till he is 18 degrees below the western horizon, when it is lost in the darkness of the night. The duration of twilight increases with the length of the day, and from the Equator towards the Poles.

☽ THE MOON.

The Moon is only a secondary Planet or Satellite to the Earth, and though the smallest, she appears to us, excepting the Sun, the largest and most splendid object in the Heavens.

By dissipating, in some measure, the horrors and darkness of our nights, by her motion and various appearances, subdividing our years into months; by regulating the flux and reflux of the sea; she not only becomes a pleasing, but a welcome object; an object affording much for speculation to a contemplative mind, of real use to the navigator, the traveller, and the husbandman.

The diameter of the Moon is 2144 miles, her circumference 6738 miles, and her magnitude about 50 times less than the Earth.* Her mean distance from the Earth is generally said to be 240 thousand miles, but in reality it is not quite 237 thousand miles; and a cannon ball would occupy nearly 3 weeks in travelling from the Moon to the Earth.†

She moves in her orbit at the rate of 2270 miles per hour,‡ and completes her revolution, from the time of her being in conjunction with the Sun till she returns to it again, or from one new moon to another, in 29 days, 12 hours, 44 minutes, 3 seconds; but from any fixed star to the same star again, in 27 days, 7 hours, 43 minutes, 5 seconds: the former time constitutes a *synodical*, and the latter a *sidereal* month. The reason of this may be explained by Fig. 4, PLATE IV. Let S represent the Sun, E the Earth, M the Moon, and *c* a fixed star. In this position, the Moon will be in conjunction with the Sun and star, and it is plain, if the Earth were to continue at E while the Moon goes round it, that she would come in conjunction with the Sun and star again at the same time; therefore, if the Earth had no motion in its orbit, the synodical and sidereal months would be equal. But, as the Earth moves in its orbit about one degree at a mean rate every day, we may suppose it to have moved from E to *e*, during one revolution of the Moon. In this case, it is evident, that when the Moon arrives at *m* she will be in conjunction with the star at *c*, and her sidereal revolution will be completed; but her synodical revolution will not be finished, till she comes in conjunction with the Sun at *n*; therefore, the synodical month is so much longer than the sidereal month, by the time the Moon occupies in travelling from *m* to *n*, which is about 2 days, 5 hours.

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* The cube of the Moon's diameter is 9855401984, and that of the Earth is 495289174528; hence, 495289174528 ÷ 9855401984 = 50 times the Moon is less than the Earth.

† For, As 480 miles : 1 hour :: 237000 miles : 493 hours, 45 minutes, or 2 weeks, 6 days, 13 hours, 45 minutes.

‡ The distance of the Moon from the Earth is 237000 miles, therefore the circumference of her orbit must be 1489714 miles, which she completes in 27 days, 7 hours, 43 minutes, or 656 hours nearly; hence, As 656 hours : 1489714 miles :: 1 hour : 2270 miles, the rate of her travelling per hour.

The Moon constantly keeps the same side towards the Earth, which is known by the spots always appearing in the same position on her disc; hence every part of her surface is turned towards the Sun, in the same time as she occupies in going round the Earth, therefore her days are as long as $29\frac{1}{2}$ of ours. As the Moon goes round the Earth nearly thirteen times during his annual motion round the Sun, it is evident, that her year consists of something less than thirteen of her days.

Her axis is nearly perpendicular to the plane of the Ecliptic, consequently she can have little or no difference in the length of her days; neither can she have any diversity of seasons, unless the great length of her day be equivalent thereto; for, the Sun being above the horizon a fortnight together without setting, the morning may constitute *spring*, the middle part of the day *summer*, the evening may produce *autumn*, and the night *winter*. If this be the case, her seasons are similar to those at the poles of Venus (page 97), and return about twelve or thirteen times a-year.

The Moon being an opaque globe like the Earth, shines only by the light she derives from the Sun, therefore only that half of her surface which is turned towards the Sun can be illuminated by his rays at one time; hence she presents to our view different phases or portions of her enlightened side, according to her position with respect to the Sun and Earth.

The phases of the Moon may be illustrated by Plate IV. Fig. 5, in which S represents the Sun, T the Earth, RO a part of its orbit, and A B C D E F G H the Moon in eight different parts of her orbit, which are delineated as she would appear to a solar spectator: on the outer circle her phases are shewn as they appear to a spectator on the Earth.

When the Moon is at A, her dark half is turned towards the Earth, and she disappears as at *a*; she is then said to change. When she comes to her first octant at B, a quarter of her enlightened side is turned towards us, and she then appears *horned* as at *b;* in this position she is generally called the *new moon.* When she has gone through a quarter of her orbit, she shews us half of her enlightened side as at *c*, and we say that she is a *quarter old.* At D she is in her second octant, and by shewing us more than half her enlightened side, she appears *gibbous* as at *d.* At E her whole enlightened side is towards the Earth, she then appears with a round face as at *e*, and is termed the *full moon.* Thus in going from A through C to E, the Moon seems continually to increase; and it is plain, from an inspection of the figure, that she appears to decrease in the same proportion as she goes from E through G to A; exhibiting similar phases at F as at D, at G as at C, and at H as at B.

It is mid-day on the Earth at *i*, and midnight at *l;* morning at *m*, and evening at *k:* hence, the Moon is seen in the evening at *k* during the first and second quarters, and in the morning at *m* while she is passing through her third and fourth quarters. When the Moon is at A, she comes to the Meridian with the Sun at noon, and is said to be in *conjunction* with him. When *full* at E, she souths at midnight, because she is then in *opposition* to the Sun.

Suppose you were standing on the Earth at *m*, and looking towards the Moon in the outer circle; it will be clearly seen that her enlightened part is towards the east or left hand during the third and fourth quarters. Turn the Plate bottom upwards, and, supposing you were standing at *k*, it will be equally manifest, that her illuminated side is towards the west or right hand in the first and second quarters; and in both cases, it is always turned towards the Sun, which prove that she is a globular body, and that she derives her light from that luminary.

The Moon is frequently visible in the afternoon, east of the Sun, during the first quarter; and in the morning, west of him, while she is in her third quarter; when, if the Sun shines, she will afford an opportunity of trying a very amusing and instructive experiment. Put a small white ball on the top of a post, or on a prop at the window, and place yourself in a situation, so that the lower horn of the Moon may be seen just over the top of the ball; then, if the Sun shines on the ball, the enlightened parts of it will appear exactly of the same shape as the Moon, horned as she is, and inclined the same way to the horizon. The reason of which is plain, for both being globular, and receiving their light from the Sun, when they are viewed from the same position of your eye, you must see as much of the illuminated part of the one as of the other.

The Earth is a Moon to the Moon, waxing and waning regularly, but appearing thirteen times larger, and affording her thirteen times more light than she does to us. When she *changes* to us, the Earth is *full* to her; and when she is in her *first quarter* to us, the Earth is in its *third quarter* to her. For, when the Moon is at A, the whole enlightened side of the Earth is towards the Moon; and when the Moon is at E, *full* to the Earth, its dark side is towards her: hence, when we have a New Moon, the lunarians have a Full Earth; and a New Earth, when we have a Full Moon. The dark part of the Moon is often seen by the naked eye, when she first becomes visible after the change, in consequence of the light which the Earth reflects upon her.

That half of the Moon which is next to us is never left in darkness, for when it is turned from the Sun, it is illuminated by the Earth in the same manner that we are enlightened by the Moon; but the other hemisphere has alternately a fortnight's light direct from the Sun, and a fortnight's darkness. Hence, the inhabitants, if any, who reside in the central part of the nearest hemisphere, have the Earth constantly over their heads; while those on the borders see it continually in the horizon. But those who inhabit the opposite hemisphere can never see the Earth, unless they undertake a journey for that purpose, to effect which, those coming from the central parts must travel nearly 1700 miles to gratify their curiosity.*

To the inhabitants of the Moon, the Sun and stars appear to rise in the east, and after an elapse of about $14\frac{3}{4}$ of our days, they set in the west; but the Earth, where it is visible, continues in the same part of the Heavens, and as it turns round on its axis, the several continents and oceans appear to them like so many spots of different forms and brightness, moving over its surface. An eclipse of the Sun to us, may be termed an eclipse of the Earth to the lunarians; and when we have an eclipse of the Moon, they have an eclipse of the Sun.

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* The circumference of the Moon is 6738 miles, a quarter of which is $1684\frac{1}{2}$ miles, the distance they would have to travel.

The *apparent* diurnal motion of the Moon from east to west, is occasioned by the contrary motion of the Earth on its axis;* her *real* motion round the Earth being from west by south to east, which may be easily proved by taking particular notice what star she is near on any night, for she will be found to have moved 13 degrees to the east of that star on the following night; and by repeating the observation, she may be traced through all the signs of the zodiac.

This progressive motion of the Moon in her orbit, causes her to rise to the inhabitants of the Equator about 50 minutes later every night; but in the latitude of London, owing to the different angles which her orbit makes with the horizon, she sometimes rises an hour and a quarter, and at other times only a quarter of an hour later than the day preceding.

The greatest difference of time between her rising occurs when she is in the signs Virgo and Libra, and the least when she is in the opposite signs Pisces and Aries. Although the Moon passes through these signs every month, yet nothing very remarkable occurs to excite our attention, except in the months of September and October; when the Moon, being *full* in Pisces and Aries, rises to us for a week together nearly at the same time; the daily difference being only from 17 to 25 minutes. The Full Moon, therefore, rising for several nights soon after Sun-set, lengthens out the day, and affords the husbandmen a longer time to gather in the fruits of the fields: hence they have given the Full Moon at this season, the appellation of the Harvest Moon. As there are two Full Moons in the above months, that which happens in October is called the Hunter's Moon.

The dark shades on the surface of the Moon, which are visible to the naked eye, when viewed through a good telescope, appear to be the result of a diversity of mountains and valleys. Some of which may be clearly discerned with a common telescope either before or after the *full,* by the indented or jagged appearance of that edge of her illuminated disc which is farthest from the Sun.

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* See pages 60 and 73.

The elevation of some of the lunar mountains has been supposed to be four or five miles; but Dr. Herschel has determined from a number of careful observations, that very few of them exceed half a mile in height, and only one a mile and a half high.

It is supposed that no seas of vast extent exist on the surface of the Moon, though it is admitted that there may be small lakes and rivers. In the year 1787, Dr. Herschel discovered three volcanoes in the dark part of the new Moon. Two of them appeared to be nearly extinct, or otherwise in a state of going to break out; the third shewed an actual eruption of fire or luminous matter.

The surface of the Moon is nearly as well known to Astronomers, as the Earth is by a map to Geographers, for they have not only determined the latitudes and longitudes of the principal mountains, valleys, lakes, &c. but have constructed maps, on which they are represented as they appear when seen through a telescope of high magnifying powers, and have distinguished them by the names of celebrated astronomers and philosophers of ancient times.

The existence of a lunar atmosphere has long been a contested point among philosophers, the discovery of which appears to have been reserved for the celebrated M. Schroeter, who has not only determined its existence, but has calculated that it is sufficiently dense at the height of 5742 English feet, to inflect the solar rays.

♂ MARS.

MARS is the least bright of all the Planets, and may be easily distinguished in the Heavens by his dusky red appearance; which is accounted for by his having a very dense atmosphere, for even the stars change their colour and grow dim when they come within its influence. His orbit is next beyond that of the Earth, in consequence of which he is called the first of the *superior planets.*

The mean distance of Mars from the Sun is nearly 145 millions of miles, and a cannon ball would not fly to him, if projected from the Sun, in less than 34 years.* He moves in his orbit at the rate of 55 thousand miles per hour, † and completes his revolution round the Sun in 1 year, 321 days, 23 hours, 15 minutes, 44 seconds; or 1 year, 11 months, 14 days nearly, which is the length of his year.

The rotation of Mars on his axis is performed in 24 hours, 39 minutes, 22 seconds: hence his day and night together is 39 minutes, 22 seconds longer than ours. His Equatorial inhabitants have somewhat more than 668 artificial days and nights in their year.‡

Mars is not so much confined in his apparent motion in the Heavens, as the *inferior planets* Mercury and Venus are, but is seen at all possible angular distances from the Sun; sometimes appearing in the south soon after Sunset, and at other times in the east. His distance from the Earth is so variable at different times, that when he is in conjunction with the Sun, he is nearly five times farther from us than he is at the time of opposition. This has a very sensible effect on the apparent size of the Planet, causing him to appear much less when in the former situation than in the latter. The best time for viewing the spots on his surface, is when he appears in the eastern part of the Heavens early in the evening; or when he passes the meridian about midnight: for at that time he makes his nearest approach to the Earth.

With the assistance of a telescope, this Planet exhibits an oval or gibbous form, which is first observable after he emerges from the Sun's rays, and is seen about 50 or 60 degrees east of the Sun; and continues more or less so till a few weeks before he arrives in opposition, when he appears with a full orb. Shortly after the opposition, he again assumes an oval shape, which he continues till he comes within 50 or 60 degrees on the west side of the Sun, when he again appears with a round face.

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* For, As 480 miles : 1 hour :: 145000000 miles : 302083 hours, or 34 years, 6 months, 7 hours.

† By the rule in the first note, page 93, the circumference of the orbit of Mars will be found to be 911428571 miles, which he describes in about 687 days, or 16488 hours: hence, As 16488 hours : 911428571 miles :: 1 hour : 55278 miles, the rate of his travelling per hour.

‡ For, by inverse proportion, As 24 hours : 687 days :: 24 hours, 39 minutes : 668·88 days in their year.

The diameter of Mars is 4218 miles, and his magnitude about six and a half times less than the Earth.* His axis is inclined to the plane of his orbit in an angle of 59° 22′: consequently his seasons, with the increase and decrease in the length of his days, differ very little from ours. The length of his longest day, at the same distance from his Equator as London is from ours, is about 18½ hours; and the meridian altitude of the Sun about 69 degrees. The shortest day is only 5½ hours long, and the Sun's meridian altitude, at that time, only 8 degrees: therefore, there is only about 2 hours difference between the length of his longest and shortest day, and those at London; and only 7 degrees difference in the corresponding altitudes of the Sun.

No satellite or moon has yet been discovered to attend on Mars, neither is it probable that he has one. This circumstance induced M. Fontenelle to imagine that he is phosphorescent, and gives out during night, a portion of that light which he imbibes by day.

From the great extent and density of his atmosphere, we may reasonably suppose that it is capable of refracting the Sun's rays at a much greater height than that of our Earth; consequently the Sun will appear above his horizon, much earlier in the morning and later in the evening, than the actual time of his rising and setting. His twilight also will be proportionally longer than ours, which will compensate in some measure for the want of a moon.

To the inhabitants of Mars, the Sun appears only half the size he does to us. Mercury is seldom or ever seen, except when he transits the Sun's disc. The oscillations of Venus seem as much contracted to them as those of Mercury do to us. The Earth appears about the size of Venus, with similar phases; and is by turns, his morning and evening star. It sometimes, though very rarely, is seen passing over the Sun's face in the shape of a round black spot.

* The cube of the Earth's diameter is 495289174528 miles, and that of Mars is 75044648232 miles; the former being divided by the latter, gives 6·59, or a little more than 6½ times less than the Earth.

ASTEROIDS.

This is a general term applied by Dr. Herschel to the four Planetary Bodies recently discovered, namely Vesta, Juno, Ceres, and Pallas, in consequence of their being found to deviate so much in the form and position of their orbits, from that of the old Planets. Their orbits are situated between those of Mars and Jupiter.

⚶ Vesta was discovered while in the constellation Virgo, by Dr. Olbers, at Bremen in Germany, on the 29th of March, 1807. It appears like a star of the fifth or sixth magnitude, and may be seen sometimes, in a very clear evening, by the naked eye. Its mean distance from the Sun is about 238 millions of miles. It performs its annual revolution round the Sun in 3 years, 8 months, 2 weeks, 2 days, in an orbit which is inclined 7° 8′ to the plane of the Ecliptic.

⚵ Juno was discovered in the constellation Pisces, by Mr. Harding, at the observatory of Lilienthal, near Bremen, on the 1st of September, 1804. Its diameter is 1425 miles. It appears, when seen through a telescope, like a star of the eighth magnitude, of a reddish colour; and is supposed to have a very dense atmosphere. Its mean distance from the Sun is 253 millions of miles; and its periodical revolution is completed in about 4 years, 4 months, 2 weeks, 5 days. Its orbit is inclined 13° 4′ to the plane of the Ecliptic: the eccentricity of which is so great, that it takes double the time in going through that half of its orbit which is farthest from the Sun, than it employs in describing the other half which is nearest to the Sun. For the same reason, its greatest distance from the Sun is nearly double its least distance from him; and though Juno at its mean distance is farther from the Sun than Vesta, yet the former approaches many millions of miles nearer to the Sun than the latter.

⚳ Ceres was discovered on the 1st of January, 1801, by Piazzi, astronomer royal, at Palermo, in Sicily, while it was passing through the constellation Taurus. Its diameter, according to Dr. Herschel, is only 163 miles; but Schroeter by his observations, makes it 1624 miles. Schroeter accounts for this difference, by maintaining, that Dr. Herschel placed his micrometer too near his eye, and that he measured only the middle part of the Planet, which appeared clear. The atmosphere of Ceres, as observed by Schroeter, is 675 miles high, and is subject to many changes, which produce a singular effect in the apparent diameter of the Planet. Its orbit is inclined 10° 27′ to the plane of the Ecliptic. This Planet is of a ruddy colour, and appears about the size of a star of the eighth magnitude: it is of course invisible to the naked eye.

⚴ Pallas was discovered on the 28th of March, 1802, by Dr. Olbers, at Bremen. Its mean distance from, and the time in which it revolves round, the Sun, are nearly the same as Ceres. Its diameter, as observed by Dr. Herschel, is only 80 miles; but Schroeter makes it 2099 miles. This Planet is surrounded by a very dense atmosphere, which gives it at times a ruddy appearance. The inclination of its orbit to the plane of the Ecliptic is 34° 51′, and its eccentricity nearly as great as that of Juno; so that it approaches as near to the Sun as Vesta, and recedes but little farther from him than Juno, though its mean distance from the Sun is many millions of miles greater than either of the other two Planets.

The singular phenomena of these four small Planets, have induced some astronomers to suppose that they originally formed one large Planet, which revolved round the Sun in an orbit situated between those of Mars and Jupiter; and that it is probable that other fragments of it, in the shape of Planetary Bodies, may yet be discovered. For says Dr. Brewster, "If we suppose these bodies to be independent Planets, as they must be if they did not originally form one, their diminutive size, the great eccentricity and inclination of their orbits, and their numerous intersections when projected on the plane of the Ecliptic, are phenomena absolutely inexplicable on every principle of science, and completely subversive of that harmony and order which before the discovery of these bodies, pervaded the planetary system. But if we admit the hypothesis, that these planets are the remains of a larger body, which circulated round the Sun nearly in the orbit of the greatest fragment, the system resumes its order, and we discover a regular progression in the distances of the Planets, and a general harmony in the form and position of their orbits."

The Doctor then goes on endeavouring to prove by analogical reasoning, supported by arguments drawn from the general phenomena observed in the motions of these new Planets, "that they have diverged from one point of space, and have therefore been originally combined in a larger Planet." But do we not see a beautiful variety in all the works of creation? And shall we then accuse the great Architect of the Universe, of introducing disorder in the arrangement of the planetary system, or of having destroyed this imaginary Planet, with all its inhabitants (for they are all supposed to be inhabited), because he has introduced that variety? Nay, rather let us admit the hypothesis, that they are independent Planets, and that they were originally intended to occupy that part of the solar system, in which they now move.

♃ JUPITER.

The magnitude of Jupiter far exceeds that of either of the other Planets, being upwards of 1400 times greater than the Earth.* The diameter of this stupendous globe is 89069 miles, and his mean distance from the Sun nearly 495 millions of miles. A cannon ball would therefore take nearly 118 years in flying from the Sun to this Planet.†

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* The cube of Jupiter's diameter is 706609918515509, which being divided by 495289174528, the cube of the Earth's diameter, gives 1426, for the number of times Jupiter is larger than the Earth.

† As 480 miles : 1 hour :: 495000000 : 1031250 hours, which is equal to 117 years, 8 months, 1 week, 3½ days.

The length of his year, or the time in which he revolves round the Sun, is 11 years, 11 months, 1 week, 14½ hours, moving in his orbit at the rate of 30 thousand miles per hour.* Jupiter revolves about his own axis in the short space of 9 hours, 55 minutes, 37 seconds, which is the length of his day and night together; consequently the inhabitants of this Planet have 10476¼ artificial days and nights in their year,† each being about 5 hours long.

The axis of Jupiter being nearly perpendicular to the plane of his orbit, he can have no perceptible difference in his seasons, or in the length of his days; which is so advantageous to his inhabitants, that we may easily discover in it that wisdom, which is every where displayed in the works of our beneficent Creator. For, if his axis had been inclined any considerable number of degrees, just so many degrees round each pole would have been involved in darkness for nearly six of our years together; and as Jupiter is such an immense size, vast regions of land about his poles must have been uninhabitable.

The form of Jupiter is that of a much flatter oblate spheroid than the Earth (see page 50), the proportion between his equatorial and polar diameters being as 13 to 14, which makes the former measure 6000 miles more than the latter; a consequence which results from the rapidity of his diurnal rotation.

The brilliancy of Jupiter is excelled by none of the other Planets, except Venus when she is in the inferior part of her orbit; and, like Venus, he becomes our morning star when he precedes the Sun, and an evening star when he follows the Sun.

In viewing Jupiter through a telescope, several obscure stripes called belts or zones are perceived crossing his disc, in lines parallel to his Equator. These belts are subject, however, to great variation both in number, distance, and position. Sometimes seven or eight have been seen, and at other times only one. They have also been observed to increase and diminish alternately, to blend one with another, and to separate into others of a smaller size.

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* The circumference of Jupiter's orbit will be found to be 3111428571 miles, which he completes in 11 years, 315 days, 14 hours, or 104000 hours: hence, As 104000 hours : 3111428571 miles :: 1 hour : 29917 miles per hour, his rate of travelling.

† For inversely, As 24 hours : 4333¼ days :: 9 hours, 55 minutes, 37 seconds : 10476¼ days.

Various opinions have been entertained by astronomers as to the cause of these appearances, but that of Dr. Brewster appears to be the most rational. He supposes, "That the clouds of Jupiter, partaking of the great velocity of his diurnal motion, are formed into strata parallel with the Equator; that the body of Jupiter reflects less light than the clouds, and that the belts are nothing more than the body of the Planet seen through the parallel interstices which lie between the different strata of clouds."

Large dusky spots have frequently appeared in or between the belts, most of which varied in their form, and in the period of their rotation: hence they are supposed to be clouds floating in his atmosphere, which are transported by the winds with different velocities. Some brighter spots, more permanent than the others, have been observed also on the surface of Jupiter, which have re-appeared after unequal intervals of time. The remarkable spot, by which the rotation of Jupiter on his axis was first ascertained, disappeared in the year 1694, and was not seen again till 1708, when it re-appeared exactly in the same place, and has been occasionally seen ever since. This spot is supposed to be permanently fixed on the body of the Planet, and that its disappearance is occasioned by the interposition of the clouds in his atmosphere.

Jupiter is accompanied round the Sun, by four Satellites or Moons, discovered by Galileo, in the year 1610. They are invisible to the naked eye, but through a telescope they have a very beautiful appearance. Their respective distances from Jupiter, and the period of their revolutions round him, are as follows :—

	miles.		*d.*	*h.*	*m.*	*s.*
The distance of the first is	252510	and its period	1	18	27	33
--- --- --- second	400810	- -	3	13	13	42
--- --- --- third	640406	- -	7	3	42	33
--- --- --- fourth	1126723	- -	16	16	32	8

The circles or orbits in which these Satellites revolve, being seen obliquely by us, they seem to move in straight lines, making oscillations on each side of Jupiter. It is by the extent of these oscillations that their order, distances, and periodical revolutions, have been discovered, that being called the first and nearest, which oscillates the least. These Satellites receive their light from the Sun, and reflect it upon Jupiter, in a manner similar to that in which the Moon reflects her light upon the Earth; and, like the Moon, they are subject to be eclipsed by passing through the shadow of Jupiter. The first, second, and third, are eclipsed in every revolution, but the orbit of the fourth being inclined to the orbit of Jupiter, it generally passes either above or below his shadow, at least two years in six. The time when the eclipses occur is set down on page 3d of the month in the Nautical Almanac, and that of the first is given in page 36 of White's Ephemeris, calculated to mean time for the meridian of the Royal Observatory at Greenwich.

The eclipses of these Satellites are well known to afford the readiest method of ascertaining the longitude of places on land; and it is by means of these eclipses that geographical knowledge has been so much extended since the invention of telescopes.

The apparent positions of the Satellites with respect to each other, and to Jupiter, are given in the 12th page of each month in the Nautical Almanac; at such an hour of the night as they are most likely to be observed. The following is a specimen for the month of September 1830, as they will appear at 8 o'clock each evening.

Dates, 1830.	*Configurations at* 8 *o'clock in the evening.*
September 23.	·1 ○ ·3 ○ 2· 4·
24.	1· ● 2· ○·3 4·
25.	·2○ ·1 ·3 4· ●
26.	4· 1· ○ 2· 3·
27.	2· ● 4· ○ 3 & 1

In the above configurations, Jupiter is distinguished by the central mark ○, and the Satellites by points, with figures annexed, the figure 1 signifying the first Satellite, 2 the second Satellite, &c. The figures are placed on that side of the point towards which the Satellites are moving. Thus, on the 26th day, the first and fourth will be on the left hand, or east of Jupiter, receding from him ; and the second and third will be on the right hand or west of Jupiter, approaching him. This mark ☌ signifies that the Satellites, the numbers of which are attached to it, will be in conjunction : an example of this occurs on the 27th day, when the first and third will be in conjunction west of Jupiter. The cipher ○ occasionally placed near the margin, signifies that the Satellite, according to its number, will appear on the face of Jupiter in the form of a bright spot ; and the black mark ● signifies that the Satellite will be eclipsed, either by passing through the shadow of Jupiter, or by going behind his body. Thus, on the 23d day, the first Satellite will appear on the face of Jupiter ; and on the following day, the same Satellite will be eclipsed by Jupiter.

The method of ascertaining the longitude of a place by these eclipses, is as follows :—Suppose, that on the 24th of September, 1830, the time of the Emersion of Jupiter's first Satellite be observed with a telescope, in an unknown meridian, to happen at 10*h*. 2*m*. 13*s*. ; and the observer finds, by referring to the table, page 3d of the month in the Nautical Almanac, or page 36 of White's Ephemeris, that the Emersion happened at the Observatory of Greenwich, at 8*h*. 46*m*. 13*s*. of the same day. The difference of time between the meridians of the two places, is 1 hour, 16 minutes ; then say, As 1 hour is to 15 degrees, so is 1 hour, 16 minutes to 19 degrees, the longitude of the place of observation to the east of Greenwich, because the time is more at the former than at the latter place.

By these eclipses also, astronomers have discovered that the rays of light come to us from the Sun in 8¼ minutes ; consequently light must travel at the astonishing rate of nearly 200 thousand miles in one second of time, which is more than a million times swifter than the motion of a cannon ball.

To the inhabitants of Jupiter, the four Satellites afford a very pleasing spectacle ; for sometimes they may be seen rising all together, at other times one may be rising in the east, another on the meridian, and the other two about to set in the west. The Sun appears to them only one twenty-seventh the size he does to us. Mercury, Venus, the Earth, and Mars, they never see, because at his immense distance, these Planets always appear to accompany the Sun, and to rise and set with him. The Heavenly Bodies, therefore, which they have for the objects of contemplation, besides the Sun and Fixed Stars, are his own Moons, the Planets Saturn with his Ring and seven Satellites, Herschel with his six Satellites, and occasionally the Comets.

♄ SATURN.

Before the discovery of Herschel, Saturn was considered as occupying the utmost limits of the Planetary System. He is however the most remote Planet that can be well discerned by the naked eye; and may be known by the pale feeble light which he affords. His mean distance from the Sun is about 907 millions of miles, so that a cannon ball would not reach him from thence in less than 215½ years.[*]

Saturn completes his revolution round the Sun in 10759 days, 2 hours nearly, or 29 years, 5 months, 3 weeks, 5 days, 20 hours, moving in his orbit at the rate of 22 thousand miles per hour.[†] His diameter is 78730 miles; hence he must be about 985 times larger than the Earth.[‡] The period of his rotation on his axis, or the length of his day and night together, is 10 hours, 16 minutes, 2 seconds; and his Equatorial inhabitants have about 301797 artificial days and nights in their year.* His axis being inclined to the plane of his orbit 60 degrees, he must have some change in his seasons, and in the length of his days and nights, at those parts which are remote from his Equator.

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[*] For, As 480 miles : 1 hour :: 907000000 miles : 1889583 hours, or 215 years, 7 months, 1 week, 21 hours.

[†] The circumference of Saturn's orbit is 5701142857 miles, which he performs in 10759 days, 2 hours, or 258218 hours: hence, As 258218 hours : 5701142857 miles :: 1 hour : 22078 miles, his rate of travelling per hour.

[‡] The cube of Saturn's diameter is 488001047617000 miles, and that of the Earth is 495289174528 miles; the former being divided by the latter will give 985, the number of times Saturn is larger than the Earth.

The telescopic appearance of Saturn is the most beautiful and interesting of any Planet in the System; for, besides seven Satellites which constantly attend him, he is surrounded by two concentric thin luminous Rings, having their edge turned towards the Planet, and entirely separated from his body. The surface of Saturn is also diversified with dark spots and belts, similar to those of Jupiter: the belts in general are parallel to his rings. Dr. Herschel is of opinion, that the rings are opaque solid bodies, receiving their light from the Sun, and reflecting it upon the Planet; but casting a sensible shadow on that part of his disc from which they intercept the Sun's rays.

From the observations of Dr. Herschel, it appears that the inner ring is not less than 33807 miles from the surface of Saturn, or about one seventh of the distance of the Moon from the Earth. The breadth of the inner ring is 19024 miles, and that of the outer ring 7317$\frac{1}{2}$ miles, leaving a dark space between them of 2927$\frac{1}{2}$ miles. Hence it appears, that the breadth of the outer ring is nearly equal to the diameter of the Earth, and the inner ring nearly 2$\frac{1}{2}$ times broader.

The rings revolve round Saturn, in a plane coinciding with that of his Equator, in 10 hours, 32 minutes, 15 seconds, or in about a quarter of an hour less time than Saturn turns on his axis. As Saturn goes round the Sun, his axis, and consequently his rings, constantly keep in the same direction; therefore, being nearly 30 years in completing his periodical revolution, the Sun shines for about 15 years together on one side of his rings, and as long on the other side. The rings being seen by us in an oblique position, they generally appear in the form of eclipses, with the proportion between the major and minor axis constantly varying.

The phenomena of the rings may be illustrated by Fig. 6, PLATE IV., in which *s* represents the Sun; *e* the Earth in his orbit; *a b c d* Saturn in four different parts of his orbit; and the outer circle the Ecliptic. When Saturn is at *a* or *c* in the 19th degree of Virgo ♍, or of Pisces ♓, the outer edge of the rings is turned towards the Sun, and we lose sight of them, unless when viewed with the highest magnifying powers of the telescope, then they appear like a bright line or string crossing the disc of the Planet. As Saturn proceeds in his orbit from *a* to *b*, or from *c* to *d*, the rings appear to open gradually; and when he arrives at *b* or *d* in the 19th degree of Sagittarius ♐, or of Gemini ♊, they appear most open to our view, their breadth being then about half their length. As he moves from *b* to *c*, or from *d* to *a*, the rings become gradually narrower. At *b* the north or upper part of the rings is presented to the Sun and Earth; but at *d* the south or under side is turned both to us and the Sun.

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* For, As 24 hours : 10759$\frac{1}{12}$ days :: 10 hours, 16 minutes, 2 seconds : 301796·9 days.

In order to find the apparent shape of the rings by this figure, look first into the Nautical Almanac or White's Ephemeris, for the heliocentric longitude of Saturn, then find the same sign and degree in the outer circle of the figure, and it will be easy to determine the shape of the rings nearly, by the position of the Planet in his orbit. Thus, suppose I want to find the apparent shape of the rings on the 25th of September, 1830, I find, by the Ephemeris, that Saturn is in ♌ 23° the 23d degree of Leo: now by referring to the figure, I find that the rings will appear very narrow, because the Planet is within about one sign of *a*, where they disappear. The heliocentric longitude of the Earth at the same time is ♏ 1°; consequently Saturn may then be seen in the evening.

Saturn is attended by no less than seven Satellites, which, with his rings, supply him with light in the absence of the Sun. They revolve round Saturn from west to east in circular orbits, the planes of the first, second, third, fourth, sixth, and seventh, reckoning in order from the Planet, coinciding nearly with the plane of his rings; but the orbit of the fifth approaches more to the plane of the Ecliptic, and is supposed to turn on its axis, like our Moon, in the same time as it revolves round the Planet. The nearest two Satellites, which were discovered a century after the others, are called by astronomers the sixth and seventh, to avoid confusion in referring to former observations. Their order, distances, periodic revolutions, &c. are as follows:—

Order according to Astronomers.	*Order from Saturn.*	*Distances from Saturn in miles.*	*Periodic Revolutions.*				*By whom discovered.*
			d.	*h.*	*m.*	*s.*	
VII.	1	121244	0	22	37	23	Herschel in 1789.
VI.	2	155570	1	8	53	9	
I.	3	192613	1	21	18	26	Cassini in 1684.
II.	4	246740	2	17	44	51	
III.	5	344601	4	12	25	11	Cassini in 1672.
IV.	6	798912	15	22	41	13	Hygens in 1655.
V.	7	2328597	79	7	53	43	Cassini in 1671.

The rapid motion of Saturn on his axis, together with the attraction of his rings, produce a greater flatness about the poles of this Planet, than is observed in any of the others; his Polar being to his Equatorial diameter as 11 to 12 nearly.

To the inhabitants of this Planet, the Sun appears 90 times less than he does to us; while Mercury, Venus, the Earth, and Mars, are invisible to them on account of his immense distance. His rings appear to them alternately every 15 years, like two vast luminous arches in the Heavens, with the Fixed Stars glittering between them like so many diamonds. When the north side of the rings is enlightened, they are visible to the northern hemisphere, and vice versa; and at the same time they are not only invisible to the opposite hemisphere, but they intercept the Sun's rays from a great portion of the Planet near his Equator, which is known to be the fact by the deep shade they project on his surface.

♅ HERSCHEL.

This Planet was discovered by Dr. Herschel near the feet of Gemini, on the 13th of March, 1781; which, in compliment to his Royal Patron, he named Georgium Sidus or Georgian Star, but by most continental astronomers he is called Herschel, in honour of the discoverer; and he is otherwise known by the name of Uranus, the most ancient of all the heathen gods, from whom descended Saturn, Jupiter, and Mars.

Herschel can seldom be discerned by the naked eye, for he appears no larger than a star of the sixth or seventh magnitude. When viewed through a telescope magnifying 200 or 300 times, his disc is well defined, and he appears to reflect a bluish white light; but with instruments of a much smaller power, he can scarcely be distinguished from a fixed star. Flamstead and Mayer had previously considered him as a fixed star, and entered him as such in their catalogue.

Herschel is the most remote Planet known to exist in the Solar System; his mean distance from the Sun being 1822 millions of miles: a distance so amazingly great, that a cannon ball would not reach him from thence in less than 433 years.* His diameter is 35112 miles; consequently his magnitude is upwards of 80 times greater than that of the Earth.† He performs his annual revolution round the Sun in 83 years, 150 days, 18 hours, which is the length of his year; and he moves in his orbit at the rate of 15 thousand miles per hour. The length of his day, or the time in which he turns round on his axis, has not yet been discovered.

This Planet is attended by six Satellites, which were all discovered by Dr. Herschel, by means of his powerful telescope. Their order,‡ distances, &c., are as follows:

Order.	*Distances from ♅ in miles.*	*Periodic Revolutions.*			*Discovered in*
		d.	*h.*	*m.*	
1	224155	5	21	25	1798.
2	290821	8	16	58	1787.
3	339052	10	23	4	1798.
4	388718	13	10	56	1787.
5	777487	38	1	48	1798.
6	1555872	107	16	40	

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* As 480 miles : 1 hour :: 1822000000 miles : 3795833 hours, or 433 years, 6 days, 11 hours.

† The cube of Herschel's diameter is 43639038524928, and that of the Earth 495289174528; the greater being divided by the less gives 88 for the number of times Herschel is larger than the Earth.

‡ Mr. C. Bucke, of Pulteney Terrace, in an address to astronomers which is inserted in the Literary Gazette, July 10, 1830, recommends them to distinguish the Satellites of the several Planets by appropriate names. This would certainly, as he justly observes, remove the inconvenience attending their present numerical order, especially as the numbers are applied to those of Saturn. He proposes, "with

They revolve round their primary Planet in orbits lying in the same plane, and nearly perpendicular to the Ecliptic. Their motion is apparently retrogade, or contrary to the order of the signs, and to the motion of all the Planets and other Satellites in the System ; but this is most likely an optical illusion, arising from the difficulty of ascertaining what part of their orbits incline to the Earth. This query might be determined by their transits and eclipses, but the Planet is generally too remote for such observations.

COMETS.

Besides the regular Planets and their Satellites, which are always visible, either to the naked eye or by the aid of a telescope, there are other Celestial Bodies, which, after making a transient though a conspicuous appearance, are withdrawn from our view for a very long period. These bodies are called Comets, from the Greek word κομη (*kome*), which in Latin is *coma*, signifying hair.

They appear to belong to the Solar System, and to revolve about the Sun in very eccentric orbits or long narrow ovals, similar to that marked *e f g*, Plate III., having the Sun in the lower focus of the ellipsis ; consequently they sometimes approach very near the Sun, and at other times they recede far beyond the limits of any known Planet. Hence they are visible only when they come within the Planetary regions, or in that part of their orbits which is nearest to the Sun.

Comets are said to consist of four parts, namely, the *nucleus*, the *head*, the *coma*, and the *tail*. The *nucleus* is the small brilliant part in

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due respect to the correction of others, naming them after the following manner :"—The Satellites of Jupiter, in the order of distance, *Hebe*, *Astrea*, *Flora*, and *Pomona ;* those of Saturn, *Cybele*, *Thetis*, *Doris*, *Hygeia*, *Echo*, *Psyche*, and *Fortuna ;* and those of Herschel, *Urania*, *Calliope*, *Clio*, *Melpomene*, *Psyche*, and *Erato*. They might also, with equal propriety, be characterized by some additional mark joined to the character of their primary Planet.

the centre; the *head* includes all the very bright surrounding light; the *coma* is the hairy appearance encircling the head; and the *tail*, which is always in a direction opposite to that of the Sun, is by some supposed to consist of radiant matter somewhat similar to the Aurora Borealis, and by others to be a thin vapour, emitted from the head of the Comet by the heat of the Sun.

Comets are distinguished by the popular names of *tailed*, *bearded*, and *hairy*; these distinctions, however, do not arise from any peculiarity in the nature or construction of the Comets, but from the different positions in which they are seen from the Earth. Thus, when the Earth is at D, (PLATE III.) and the Comet at *e* or *g*, it is said to be *tailed*, because it is then seen eastward of the Sun, and appears to revolve round the Earth from east to west, with its stream of light following it; when the Earth is at B, and the Comet at *e* or *g*, it is then seen westward of the Sun, with its luminous train going before it in the manner of a beard;* and when the Sun and Comet are in opposite parts of the Heavens, the Earth being directly between them, it is then said to be *hairy*, because the greater part of the stream of light is hid behind the head, and the extremities only appear surrounding the Comet like a border of hair.

The magnitude of Comets is very different: the beautiful one which appeared in 1811, is supposed to be about the size of the Moon; but the most of those which have been observed, are thought to be much less. Seneca informs us that one which appeared in the time of the Emperor Nero, was not inferior, in its *apparent* magnitude, to the Sun himself.

It is supposed that upwards of 500 Comets have been seen since the beginning of the Christian era; but it is probable, that out of this number, many of them may have appeared several times under different circumstances; therefore their real number may be much less than that above stated.

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* This division of Comets seems to be very ill defined or misunderstood by many authors, who say, "when the Comet is eastward of the Sun, and moves from him, it is said to be *bearded*, because the light precedes it in the manner of a beard; when the Comet is *westward of the Sun, and sets after him*, it is said to be tailed." Here we find that, in the former position of the Comet, its name is determined from its *real* motion, and in the latter, neither its *real* nor *apparent* motion is regarded. How can a Comet or any other Celestial Object *set after the Sun when it is westward of him?* Now I apprehend that these distinctions are applicable to them only with respect to their apparent diurnal motion from east to west round the Earth, as above described, that being the only motion which is evident to spectators generally.

Some of the Comets move direct in the order of the signs, as from *e* to *f* and *g*, while others move retrograde in an opposite direction; and they are known to cross the Ecliptic at all possible angles. When a Comet is approaching the Sun, its motion is accelerated, and retarded when it is receding from him. Its motion is greatest when at *f* in its *perihelion*, and least when in its *aphelion*, or in that part of its orbit which is farthest from the Sun. The remarkable Comet of 1680 was calculated to move, when in its perihelion, at the rate of 1204108 miles per hour, at which time it was only 137 thousand miles from the surface of the Sun.

The elements of about 111 Comets which have been observed up to the year 1820, have been calculated, from which it appears that 25 have passed between the Sun and Mercury, 35 between Mercury and Venus, 25 between Venus and the Earth, 20 between the Earth and Mars, and 6 between Mars and Jupiter. Of this number 59 moved direct, and 52 retrogade.

The periods of three Comets are said to be ascertained from ancient observations. That of the first is about 76 years, it having appeared in the years 1531, 1607, 1682, and most probably in 1759, for the elements of all four coincide remarkably well. It may therefore be expected to return in 1835. The period of the second is about 129 years, it having appeared in 1532 and in 1661, and was expected to return in 1789-90, but it was not observed. The third is the remarkable Comet of 1680, the period of which was calculated to be about 575 years: hence the accuracy of the calculation cannot be ascertained till its period is completed in the year 2255.

The tail of the Comet which appeared in the year 1807, was ascertained to be more than 9 millions of miles in length, and that of the beautiful Comet of 1811, to be about 33 millions of miles. The tail of some have been computed to be of the astonishing length of 40, 60, or

80 millions of miles! How absurd it must be then to suppose that they consist of vapour driven off by the action of the Sun, to such an immense distance from bodies so comparatively small!!

Various opinions have been entertained as to the nature and use of Comets. By the vulgar and superstitious, they were considered to be omens of divine vengeance, of pestilence, famine, and the fall of nations. Mr. Whiston, an eccentric astronomer, regarded them as places of punishment for the damned, being alternately hurried into the terrifying extremes of intolerable cold and devouring fire. But such extravagant ideas are now deservedly ridiculed for their puerility.

By other astronomers, Comets were supposed to be destined to convey back to the Planets the electric fluid, which is continually dissipating, or to replenish the Sun with fuel, which he was supposed to be constantly consuming. The cause of the deluge has also been attributed to the tail of a Comet, on the supposition that it was composed of vapour.

But if I were allowed to express my opinion, I should assign them a much nobler rank in the Universe; and give to them the appellation of Secondary Suns. That these Secondary Suns or Comets shine by an inherent light, is evident from the observations of Dr. Herschel on that which appeared in the year 1807; for he says, "We are authorized to conclude that the body of the Comet, on its surface, is *self luminous*, from whatever cause this quality may be derived." Now the cause, I apprehend, is simply this, that Comets are surrounded by extensive, luminous, and phosphorescent atmospheres, similar to that of the Sun; with an exceedingly small nucleus, which in some are hid from our view by the density of their atmospheres.

The very large interesting Comet of 1811, as M. Schroeter observes, had the appearance of two nuclei, one within the other; the central nucleus being the most brilliant. They were surrounded by a particular kind of atmosphere, and also with a luminous nebulosity.

The rays emitted by a Comet, coming in contact with the calorific matter contained in the Earth and Planets, produce a perceptible degree of heat, which has been verified by experience, particularly during the autumnal months of 1811, when the Comet was near its perihelion.

The opinion, therefore, that Comets are exposed to the extremes of alternate heat and cold, is entirely unfounded ; for the atmosphere of the Sun and Comets being of the same quality, their rays produce no heat when united. Though heat may be produced by the mixture of two or more heterogeneous chemical fluids, yet the mingling of two homogeneous fluids will not produce a similar effect: hence the proximity of a Comet to the Sun, will be productive of no additional heat to either of them. Again, the Comets being endowed with the principle of inherent heat, they will be as warm when in aphelion as in perihelion.

The luminous stream or tail I consider to be a mere optical illusion, produced by the transmission of the Sun's rays through the dense atmosphere of the Comet, and causing a stream of light to appear in a form similar to the *penumbra* of a Planet. Thus, let S, Fig. 7, PLATE IV. be the Sun, and C and D a Comet in different parts of its orbit, then the right lines *ab, de, ac,* and *df,* will represent the rays of the Sun passing through the atmosphere of the Comet at C and D, which are refracted or bent towards each other. The spaces *b*C*e*, and *c*D*f*, will represent the tail in each position of the Comet, which appears very bright near the Comet, and gradually becomes more faint the further it extends, until it vanishes in ether. As the Comet approaches the Sun, its tail appears broader, as shewn in the figure ; it also becomes longer and more brilliant, because a greater number of the solar rays enter the atmosphere of the Comet, and with greater force, the nearer it approaches the Sun.

If the nucleus be a solid opaque body, we may conclude that it projects an *umbra*, which, in consequence of the great refractive power of the surrounding atmosphere, must terminate in a point not far behind the Comet, as shewn also in the figure ; and this *umbra* will be completely enveloped by the *penumbra* or luminous tail. Now as the Stars may be seen through the tail, and without the slightest appearance of their rays being refracted or distorted, so also the *umbra* or dark shade may be seen through it, and thus occasion the tail to appear as if detached from the head, as was observed in the Comet of 1811.

The utility of Comets, and the exact courses they run, seem to be subjects too great for the limited powers of man to comprehend. Their splendid appearance, the great extent of their orbits, and their rapid motions, together with the preceding phenomena, fully entitle them to the appellation of Secondary Suns.

THE SOLAR SYSTEM described in the preceding pages, is not a modern invention, for it was known and taught by Pythagoras, a wise philosopher of Samos, nearly 600 years before the Christian era; and after him by Philolaus, Aristarchus, and others among the ancients. But through the prejudices of succeeding ages, it was lost, or totally disregarded till the fifteenth century, when it was revived by Nicholaus Copernicus, a famous Polish philosopher, born at Thorn, in the year 1473. His endeavours to re-establish the true system of nature were followed up by the greatest mathematicians and philosophers that have since flourished, as Kepler, Galileo, Descartes, Gasscendus, and Sir Isaac Newton; the last of whom has finally established this System on such a solid basis of mathematical and physical demonstration, as can never be shaken; though a philosopher of our own age has made some fruitless attempts to overturn its physical department.

Previous to the final establishment of the Solar System, two others were introduced to the world, which were named after their inventors. The Solar System, also, is sometimes called the *Pythagorean*, from Pythagoras its inventor; the *Copernican*, from Copernicus its restorer; and the *Newtonian*, from Sir Isaac Newton its establisher.

THE PTOLEMIAN SYSTEM.

This System was invented and taught by Ptolemy, an Egyptian philosopher, who flourished about A. D. 130. He supposed that the Earth was immoveably fixed in the centre of the Universe; and that the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn, moved round it in circular orbits, as represented in Fig. 8, Plate IV.: next beyond them he placed the firmament of Stars, and then two Cristaline Spheres; all which were included in, and received motion from the Primum Mobile, or Prime Mover, which carried them round the Earth from east to west every 24 hours. But, as the retrogade and stationary appearances of the Planets could not be solved by this hypothesis, he afterwards supposed them to revolve in *epicycles* or small circles, the centres of which he supposed to be in the circle of their daily motion.

This System, erroneous as it is now proved to be, gained the ascendancy over all others, and was implicitly received by all nations from the time of Ptolemy till Copernicus, a period of about 1400 years, only because it left the Earth at rest, which accorded with the apparent evidence of their senses, and the metaphorical passages contained in the Holy Scriptures.

Other Egyptian philosophers, not being perfectly satisfied with the System of Ptolemy, supposed the Earth to be immoveable in the centre, round which revolved in order the Moon, the Sun, Mars, Jupiter, and Saturn; and to account for the retrogade and stationary appearances of Mercury and Venus, which were the most evident, they supposed them to revolve about the Sun in certain periods, and with him about the Earth every 24 hours. See Fig. 9, Plate IV.

THE TYCHONIC SYSTEM

WAS invented by Tycho Brahe, a Nobleman of Denmark, who flourished A. D. 1586. This eminent philosopher, though sensible of the defects and absurdities of the Ptolemian System, was unwilling, from pious motives, to acknowledge the motion of the Earth; he therefore supposed the Earth to be the centre of the two Luminaries, the Sun and the Moon; that Mercury, Venus, Mars, Jupiter, and Saturn, revolved about the Sun in the periods previously mentioned; while the Sun, with his attendant Planets, and all the Stars, moved round the Earth once in 24 hours. See Fig. 10, PLATE IV.

Tycho found but few abettors, for his System involved the science in new difficulties; and proved to be equally as absurd, with respect to their diurnal motion round the Earth, as that of Ptolemy. Some of his disciples, therefore, supposed the Earth to turn on its axis from *west to east,* to account for the daily motion of the Heavenly Bodies from *east to west;* while the Sun, having all the Planets revolving round him as before, performed his annual motion through the several signs of the Zodiac.

This hypothesis acquired the name of the Semi-Tychonic System; which, being partly true and partly false, was embraced by few, and soon gave way to the true and rational system now universally adopted. The truth of the Solar System will be clearly seen under the following head.

THE
DESCRIPTION AND USE
OF THE
THIRD MOVEABLE PLATE.

THIS Plate comprehends a part of the Solar System, drawn on a larger scale, for the purpose of illustrating the *apparent* annual motion of the Sun in the Ecliptic; the *real* motion of the Earth in its orbit; the general phenomena of the Planets; and to exemplify the cause of the appearance of certain Fixed Stars at different times of the year.

It consists of the following particulars: 1st, A representation of the Sun in the centre. 2dly, The Planets Mercury, Venus, the Earth, and Mars, engraved on moveable levers. 3dly, The orbits of the above Planets, with the places of their nodes. 4thly, A part of the orbit of a Comet. 5thly, The Earth in four different parts of its orbit, to illustrate the four seasons of the year. 6thly, The orbit of the Moon. 7thly, The Ecliptic and Zodiac, which is divided into the 12 Signs, and contains the Figures and principal Stars of the Zodiacal Constellations, as they are represented on the Celestial Globe. 8thly, A scale to measure the distances of the Planets.

The Apparent Motion of the Sun in the Ecliptic.

A tolerably good idea of this motion may be obtained by the following simile. To a person riding along a road, or sailing on a river, the houses, trees, and other objects on each side, appear to pass by him in succession, though in reality they are stationary; so it is with respect to the Earth and objects in the Heavens, for as the Earth proceeds in its orbit, the Sun, though stationary, appears to change his place among the Fixed Stars.

Let the outer circles, which include the figures of the constellations, represent that portion of the Starry Heavens called the Zodiac; then if you bring the Earth to A in Capricornus ♑, the Sun will appear as if he were among the Stars in the opposite sign Cancer ♋; if the Earth be brought to B in Aries ♈, the Sun will appear among the Stars in Libra ♎; and if the Earth be brought to C in Cancer ♋, the Sun will appear among the stars in Capricornus ♑. In short, by moving the Earth round the Sun in the order of the signs ♈, ♉, ♊, &c., or of the letters B, C, D, A, it will be evident that to a spectator on the Earth, the Sun will appear to describe a path among the Fixed Stars in the Ecliptic, as traced out by the index; and as the Earth revolves about the Sun from west to east in a year, so the Sun appears to move from west to east round the Heavens in the Ecliptic in the same time.

It is equally plain, that if a spectator were placed on the Sun, the Earth would appear to him to describe the very same circle in the Heavens, as the Sun appears to do to a spectator on the Earth: hence, if a plane, passing through the centres of the Sun and Earth, were supposed to be extended to the Heavens, it would coincide with the Ecliptic. This imaginary plane is called the Plane of the Ecliptic or of the Earth's orbit, which may be represented by the surface of the plate.

The planes of the orbits of all the Planets are inclined more or less to the plane of the Ecliptic, as will be noticed hereafter: therefore to a spectator on the Sun, the Planets will appear to describe different circles in the Heavens, and the Sun will appear to perform the same circles, as seen by a spectator on each Planet respectively, and in the same time as they take to complete their periodic revolutions.

Now as it is impossible that the Sun can describe all these circles, and perform them in very different periods, we may safely conclude that they are all *apparent, not real,* arising from the periodical motion of the respective Planets.

Day and Night.

The Earth being an opaque spherical body, only that half of its surface which is turned towards the Sun can be illuminated by him at one time, while the other half is in darkness; the enlightened hemisphere, therefore, constitutes Day, and the darkened hemisphere Night.

As the Earth turns round on its axis, every part of its surface, excepting sometimes the poles, is carried successively through both hemispheres, and thus occasions a constant succession of Day and Night to all the inhabitants of the world, the poles as before excepted.

The cause of the Sun's apparent rising in the east and setting in the west, may be explained by the figure of the Earth on the moveable lever, as follows :—Place the Earth between yourself and the Sun, and imagine it to revolve on its axis in the order of the numbers 6, 8, 10, 12, &c. viz. from west to east. Suppose a spectator to be at 6 on the right hand, the Sun will appear to him to be *rising in the east.* As the Earth moves round, the spectator is carried from 6 towards the upper 12, and the altitude of the Sun increases; when he arrives at 12, it is *noon* with him, for the Sun is then on the meridian, having attained his greatest altitude for that day. As the Earth's motion continues, the spectator is carried from the upper 12 towards 6 on the left hand, and the altitude of the Sun decreases. When the spectator has arrived at 6 on the left hand, the Sun appears to him to be *setting in the west*, and when the spectator comes to the lower 12 it is *midnight.*

Hence it is evident, that while the spectator is carried round by the rotation of the Earth, the Sun appears to move the contrary way; and it will be easy to conceive, that as he arrives at each number, it will indicate the hour of the day or night respectively.

The diurnal rotation of the Earth accounts for the apparent daily motion of the whole Starry Heavens also. Whether we conceive the Sun to be at rest, and the Earth to revolve on its axis, or the Earth to be at rest, and the Sun to revolve round it, the appearance will be just the same. See page 60.

But, if the Sun revolve round the Earth, he must move at the rate of 400 thousand miles per minute, and the Stars at least at the rate of 33 millions of miles per minute; therefore, it is much more rational to allow the Earth, a comparatively small and single body, to turn on its axis every 24 hours, than to insist that the Sun, the Moon, and all the Stars, are carried round it, with such an inconceivable velocity.

The Phenomena of the Starry Heavens; shewing the cause of the appearance of certain Fixed Stars at different times of the Year, and at different hours of the same Night.

It is well known to almost every one, that there are certain Fixed Stars which appear in the evening at one time of the year, and not at another. For instance, Orion and the Pleiades are visible in the evenings during our autumnal and winter months only; and by inspecting the following Maps, the time of the year when any other constellation appears, may be easily ascertained. This phenomenon arises from the annual motion of the Earth, and the permanent situation of the Fixed Stars with regard to each other.

Let the Earth be moved gently round its orbit in the order of the letters A, B, C, D, and you will perceive that the Earth passes by all the Stars in the Zodiac in one entire revolution: consequently it brings a fresh constellation of stars on the meridian at midnight every month, and the whole in the course of the year. When the Earth is at A, the Stars in the Bow of Sagittarius appear on the meridian at midnight; those in Virgo at 6 in the evening; and those in Pisces at 6 in the morning: while those in Taurus and Gemini are rendered invisible by their proximity to the Sun. In the space of three months after the Earth arrives at B, the Stars in Pisces are then on the meridian at midnight; and those on the opposite signs Leo and Virgo are lost to our sight in the superior rays of the Sun.

Hence it appears, that the annual motion of the Earth causes the Stars to culminate six hours earlier in the space of three months; two hours earlier every month; and about four minutes earlier every day. This may be proved by observing at what time in the evening any remarkable Star comes in a line with the wall of a building, or a rod fastened to the side of a window; for the next evening the same Star will be in a line with it nearly four minutes earlier.

Since a spectator is carried round, by the rotation of the Earth on its axis, every 24 hours, as already noticed (page 132), all the Stars in the Zodiac seem to pass by his meridian in the same time; therefore, the same change of Stars is produced at different hours of the same day by the rotation of the Earth on its axis, as there is at midnight in the several months of the year by its annual motion round the Sun.

For when the Earth is at A, the same Stars are visible *at* 6 *in the evening*, as *at midnight* when the Earth is at B; and the same *at* 6 *in the morning* at A, as *at midnight* when the Earth is at D. Hence all the Stars are visible in the course of the night, excepting those in the vicinity of the Sun, and those which never rise in the latitude of the place of observation. See Problem IV., page 75.

For the same reason, all those Stars which are on the meridian at midnight on the first day of any month, will be on the meridian two hours earlier, or at 10 o'clock in the evening on the first of the following month; and two hours later, or at two o'clock in the morning on the first of the preceding month.

In all problems on this plate, the surrounding Stars must be considered as being at an immeasurable distance from the Sun and Earth. Indeed, their distance is so immensely great, that although we are 190 millions of miles, the whole breadth of the Earth's orbit, nearer to some of them at one time of the year than at another, yet they always appear of the same magnitude, and in the same position with respect to each other. Let D be the place of the Earth in Spring, and B its place in Autumn, then it is plain, that the Earth is the whole breadth of its orbit, or 190 millions of miles, nearer to the Stars in the neck of Virgo in Spring, than it is in Autumn; and yet, as before mentioned, there is no perceptible difference in their apparent magnitudes. This is not only a proof of the immense distance of the Fixed Stars, but that they shine by their own light also, for it is impossible, at such vast distances, that they can receive so strong a light from the Sun as they shine with.

The Seasons ; Long and Short Days ; Polar Day and Night.

THESE phenomena are produced by the annual motion of the Earth round the Sun; combined with the *inclination* and *parallelism* of its axis. The Earth's axis inclines 23½ degrees from a perpendicular to the plane of the Ecliptic; and in the course of its periodical revolution, it constantly points towards the same Star in the Heavens. To explain this, elevate the north pole of the Globe (PLATE I.) 66½ degrees above the north point of the horizon, the Ecliptic will then coincide with the horizon, the first degree of Capricornus ♑ will be at S in the South, and the first degree of Cancer ♋* at N in the North.

By this position of the Globe, it will be easy to perceive that the Earth's axis *n s* inclines to the Ecliptic in an angle of 66½ degrees, or from the perpendicular to it, in an angle of 23½ degrees; and that the whole of the Arctic Circle, the (dotted) Parallel of London, the Tropic of Cancer, and half the Equator, are above the horizon, or above the plane of the Equator.

From this side view of the Globe, I shall now suppose the eye of the student to be placed in the Zenith, looking down upon it, the above-named circles will then appear as at C, (Plate III.) with the north pole inclining towards the first degree of Cancer ♋, as in the side view, Plate I.

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* The character ♋ of this sign is not engraved on this Plate, but on its corresponding point in PLATE II.

As the Earth revolves in its orbit round the Sun, the north pole does not incline to different parts of the Heavens as in that engraved on the lever, but constantly keeps in the same direction, as at A, B, C, and D. This property is technically termed *the parallelism of the Earth's axis*, because it keeps parallel to itself in every part of the Earth's orbit.

The Vernal Equinox takes place about the 20th of March, when the Earth is at D in the first degree of Libra ♎; and the Sun, as seen by us, appears in the opposite sign Aries ♈. The Autumnal Equinox takes place on the 23d of September, when the Earth is at B in the first degree of Aries ♈, and the Sun, as seen by us, appears in the first of Libra ♎. In both of these situations, the Sun, being vertical to the Equator, enlightens the Earth from pole to pole; and as all the circles are equally divided by the boundary between light and darkness, it is *equal day and night* to all the inhabitants of the world. See also B and D, Fig. 11., Plate IV. For as a spectator, situated on either of those circles, is carried round by the motion of the Earth on its axis, he passes through as much of the enlightened, as of the darkened, hemisphere.

The Earth is at A in the first degree of Capricornus ♑ on the 21st of June, when the Summer Solstice takes place; and the Sun as seen by us, appears in the first of Cancer ♋. The north pole then inclines towards the Sun, so as to bring the whole of the Arctic Circle, the greater part of the Tropic of Cancer, and the Parallel of London, into the light: consequently the days in the northern hemisphere are then at the *longest*, and the nights at the *shortest*. See also A, Fig. 11, Plate IV.

The Winter Solstice takes place about the 22d of December, when the Earth is at C in the first degree of Cancer ♋; and the Sun as seen by us, appears in the first of Capricorn ♑. The north pole then declines from the Sun, so that the above-named circles are as much in the dark as they were before in the light: hence the days in the northern hemisphere are then at the *shortest*, and the nights at the *longest*.

In every situation of the Earth in its orbit, the Equator is equally divided by the boundary between light and darkness: consequently the Equatorial inhabitants have *equal day and night* throughout the year. See page 68.

The heat of Summer and the coldness of Winter, depends principally on the degree of perpendicularity with which the Sun's rays fall upon the surface of the Earth. In June the Sun is vertical to the Tropic of Cancer, and he then attains his greatest altitude in the Heavens; consequently his rays fall more perpendicularly upon us, and strike the Earth with more force, as well as in greater numbers on the same place; which, together with the great length of the day, cause the heat of Summer. For the Earth and Air acquire more heat by day than they lose by night; and as long as they continue so to do, the heat will increase. But in December the Sun is vertical to the Tropic of Capricorn, and although he is then upwards of three millions of miles nearer to us than in June, yet his rays fall so very obliquely and feebly upon us, that the little heat which the Earth and Air imbibe by day is entirely lost by night.

That there is but one day and one night in the year at the poles, each six months long, will appear evident from an inspection of this plate, or of Fig. 11, PLATE IV. For the north pole continues in the light from the 20th of March to the 23d of September, or while the Earth is moving from D to A and B; and from the 23d of September to the 20th of March, or while the Earth is moving from B to C and D, the north pole is constantly in the dark; therefore, whilst the north pole is in the light there can be no night, and whilst it is in the dark there can be no day.

It will also be seen by the last figure, that when it is day at the north pole, it is night at the south pole; and when it is summer in the northern, it is winter in the southern, hemisphere; and vice versa.

If the Earth's axis were perpendicular to the plane of the Ecliptic, or although it is inclined to it, yet if it did not keep parallel to itself during the annual motion of the Earth round the Sun, we should have no diversity of Seasons, and the days and nights would always continue of the same length.

The Precession of the Equinox.

It has already been proved (pages 53 and 54), that by the rotation of the Earth on its axis, there is more matter accumulated about the Equatorial, than any other parts of the Earth.

The Sun and Moon, by attracting this redundancy of matter, bring the Equator sooner under them in every return towards it, than if no such accumulation existed. Therefore, if the Sun sets out from any Star or other fixed point in the Heavens, the moment he departs from the Equinoctial or from either Tropic, he will come to the same Equinox or Tropic again 20 minutes, 24 seconds of time,* before he arrives at the same Fixed Star or point from whence he set out.

As the Sun apparently describes the whole Ecliptic or circle of 360 degrees in about $365\frac{1}{4}$ days, he moves 59′ 8″ of a degree every day at a mean rate, which is equal to 50″ of a degree in 20 min. 24 sec. of time ;† therefore he will arrive at the same Equinox or Solstice when he is 50″ of a degree short of the same Star or fixed point in the Heavens from which he set out the year before. So that, with respect to the Fixed Stars, the Sun and Equinoctial points recede, as it were, 30 degrees westward in 2160 years,‡ or which is the same thing, the Stars appear to have advanced 30 degrees, or one sign, forward in the Ecliptic during that time.

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* The difference of time between the Solar or Tropical and the Sidereal year. See page 98.

† For, as 24 hours : 59′ 8″ :: 20 min. 24 sec. : 50″. 26.

‡ There are 108000 seconds in 30 degrees, for 30 × 60 × 60 = 108000 ; therefore, As 50″ : 1 year :: 108000″ : 2160 years. And 2160 × 12 = 25920 ; hence the Equinoctial points will make a complete revolution through all the 12 signs of the Ecliptic in 25920 years.

To elucidate this, let those points of the Ecliptic marked ♈ and ♎, represent the present Equinoctial points; and those marked ♉ and ♏, represent the places where they were 2160 years ago, when the figures of the constellations corresponded with the signs of the Ecliptic. Then as the Vernal Equinox took place about 2160 years ago, when the Earth was opposite the sign ♏, the Sun then appeared in a line with the Star in the horn of Aries; but in every succeeding year, the Vernal Equinox took place when the Sun appeared in a point 50 of a degree short of that Star. Hence, if that part of the Ecliptic which is between ♉ and ♈ were divided into 2160 equal parts, each part, reckoning from ♉, would represent the Sun's place at the time of every Vernal Equinox since the commencement of that period.

In consequence of this retrograde motion of the Equinoctial points, and with them all the signs of the Ecliptic, the longitude of the Stars must continually increase. See longitude, page 45. Hence, those Stars which, in the infancy of Astronomy, were in Aries, are now in Taurus, those of Taurus in Gemini, &c., as may be seen by an inspection of this Plate, or of the Celestial Globe, PLATES I. and II. Hence also it is, that those Stars which rose or set at any particular season of the year, in the times of Hesiod, Eudoxus, Virgil, Pliny, &c., do not at this time answer the description they have given of them.

The real and apparent motion of the Planets; their Direct, Retrograde, and Stationary appearances; Conjunctions and Oppositions.

ALL the Planets revolve round the Sun from west to east, and if seen from him, they would appear to move in an uniform and regular manner, according to the order of the signs ♈, ♉, ♊, &c. But, as seen from the

Earth, or any other Planet, their motions are apparently very irregular; for they sometimes appear to go *forward*, sometimes *backward*, and at other times to remain *stationary*.

While the inferior Planets pass through that part of their orbits which is farthest from the Earth, their motions accord with the order of the signs, and are said to be *direct;* while they pass through that part which is nearest to the Earth, their motions appear to be contrary to the order of the signs, and are said to be *retrograde*; and when they change from one motion to the other, they appear to remain for some time in the same point of the Heavens, and are said to be *stationary*.

The direct, retrogade, and stationary appearances of Venus may be illustrated by the following experiment. Fasten a thread to the centre of the Earth at A, and place Venus between A and B; extend the thread over the centre of Venus to the opposite part of the Ecliptic; and the thread will then shew that Venus appears, as seen from the Earth, near the tail of the northern Fish: for it should be remembered that all the Planets appear to move within the limits of the Zodiac. By turning Venus round the Sun in the order of the letters B C D, and keeping the thread still over her centre, you will find, as she moves from B to C and D, that her motion is *direct;* and when she comes to the middle between D and A, she appears for some time to be *stationary* near the right foot of Leo (the Lion). As she moves on towards A and B, the thread will return, and shew that her apparent motion is then *retrograde;* and when she comes to the middle between A and B, she again appears *stationary*, though in fact she keeps moving.

Venus therefore appears to vibrate to and fro on each side of the Sun like a pendulum, and never departs from him beyond certain limits, which are called her greatest *elongations*. If the experiment be tried on Mercury, his apparent motions will be found similar to those of Venus; but less extensive in his elongations: the greatest elongation of Venus being 47° 48′, and Mercury's only 28° 20′.

When any two Celestial Bodies are seen in the same part of the Heavens, they are said to be in *conjunction;* and when seen in opposite parts, they are said to be in *opposition*. Mercury and Venus, having their orbits within that of the Earth, have each two conjunctions; but are never seen in opposition. When a Planet is in a line with the Sun, and between him and the Earth, it is said to be in its *inferior conjunction;* and when it is beyond the Sun, it is said to be in its *superior conjunction.*

From the inferior to the superior conjunction of Venus, she is seen on the right or west of the Sun, and becomes our *morning star;* and from the superior to the inferior conjunction, she appears on the left or east of the Sun, and is then our *evening star.* See page 96.

If the Earth continued at A, Venus would always appear to make equal vibrations on each side of the Sun, and the stationary points would always remain near the tail of the northern Fish, and the foot of the Lion; but as the Earth moves round the Sun, the stationary points, and the places of conjunction, &c., vary in every revolution. This, together with her phases (page 96), may be pleasingly illustrated by another experiment.

Place a light on a table in the middle of a room to represent the Sun, and let an assistant move a little white ball, to represent Venus, round the light, at a short distance, while you walk round the table at a greater distance; the ball will then appear to you to vibrate to and fro like a pendulum, moving quickest when nearest to you, and her places of conjunction, &c., to be in a line with different parts of the room. The enlightened part of the ball which is turned towards you, will represent her phases, appearing like a *half-moon* when stationary, *gibbous* when near her superior conjunction, and *crescented* when near her inferior conjunction. She disappears twice in each revolution, when in conjunction with the Sun.

The superior Planets are alternately in conjunction with, and in opposition to, the Sun, for when the Earth is at A, and Mars at ♑, he is in *opposition,* and rises when the Sun sets; but when he is at ♋, and the Earth at A, he is in *conjunction,* and rises and sets with the Sun.

If the Earth stood still at A, the motion of the superior Planets would always be direct; but as the motion of the Earth in its orbit is more rapid than theirs, it overtakes and passes them, and causes them to have a *retrograde* and *stationary* appearance.

Let the circle *a e r o*, (Fig. 3, Plate IV.) represent the orbit of the Earth, *m n s* the orbit of Mars and *u v w x* a part of the starry Heavens. Now if the Earth be at *a* when Mars is at *m*, he will appear at *u*; and for some time before and after the Earth arrives at *a*, he will appear *stationary* in that part of the Heavens. While the Earth moves in its orbit from *a* to *e* and *i*, if Mars continued at *m*, he would appear to move retrograde through the arc *u v w x*, and at *x* he would again appear stationary; but if, while the Earth moves from *a* to *i*, Mars moves from *m* to *n*, the arc of retrogradation would be *u v w*, and at *w* instead of *x* he would appear stationary. While the Earth moves from *i* to *o* and *a*, Mars appears to move *direct*, viz. from *w* to *u*.

If the same reasoning is applied to Jupiter, it will be evident, that while the Earth moves from *a* to *i*, he will appear to move *retrograde* through the small arc *r v s*, and his *stationary* points will be at *r* and *s*: hence the arc of retrogradation decreases as the distance of the Planets decreases.

As all these phenomena are actually observed to take place in the Heavens, they, if we had no stronger arguments, are quite sufficient to prove the truth of the Solar System, and the absurdity of the Ptolemian System. For if the Earth were in the centre, as Ptolemy supposed it to be (see page 123), the Planets would always move *direct*, and Venus would appear in opposition to the Sun once in every revolution; a situation in which she was never seen by any person.

To represent the position of the Earth, the Moon, and Planets; with their Phases, for any given day.

The position of a Planet in its orbit is determined by that sign and degree of the Zodiac in which it appears, when viewed from the Sun, and is termed its *heliocentric longitude*. White's Ephemeris, which is an Almanac published annually by the Stationers' Company, contains an account of the heliocentric places of the Planets for every six days in the year, at the bottom of the left hand page of each month. The following is an example for the month of November, 1830:

D. M.	Day decrease.	Length of day.	Helioc. Long. ♄	Helioc. Long. ♃	Helioc. Long. ♂	Helioc. Long. ⊕	Helioc. Long. ♀	Helioc. Long. ☿	♄ Rises.
	h. m.	h. m.	° ′	° ′	° ′	° ′	° ′	° ′	h. m.
1	6 56	9 38	24 ♌ 32	22 ♑ 55	22 ♈ 25	8 ♉ 34	9 ♎ 29	15 ♌ 28	0 m 38
7	7 16	9 18	24 45	23 26	25 59	14 35	19 10	14 ♍ 36	0 17
13	7 36	8 58	24 58	23 57	29 31	20 38	28 49	8 ♎ 40	11 a 51
19	7 56	8 38	25 11	24 27	3 ♉ 1	26 41	8 ♏ 27	29 8	11 27
25	8 12	8 22	25 24	24 58	6 30	2 ♊ 45	18 3	17 ♏ 18	11 0

The first column on the left hand contains the days of the month; the second column shews the increase or decrease in the length of the days since the shortest or longest day; the third column gives the length of the day; and the six following columns give the heliocentric longitudes of the Planets in signs, degrees, and minutes. Thus, the heliocentric longitude of Mercury for the 1st of November, 1830, will be found under his character ☿ and opposite the above day of the month, to be 15° ♌ 28′, that is, his place as seen from the Sun, will be in the 15th degree (omitting the minutes) of Leo ♌. Should the place of a Planet be required for any other day than those given in the table, take out the longitude for the nearest day, which will be near enough for common practice.

Therefore, by the use of the third Plate and White's Ephemeris, you may in a few minutes represent the position of the Planets in their orbits, just as they really are in the Heavens, for any day you please. Suppose, for example, you wish to represent the position of the Planets Mercury, Venus, the Earth, and Mars, for the 1st of November, 1830. By looking under the character of each Planet, and opposite the given day of the month in the preceding table, you will find that Mercury ☿ is in the 15th degree of Leo ♌; Venus ♀ in the 9th degree of ♎; the

Earth ⊕ in the 9th degree of Taurus ♉; and Mars ♂ in the 22d degree of Aries ♈.*

Having found their places as above, your next step is to mark their corresponding places on their respective orbits, in the following manner. Fix a thread to the centre of the Sun, by passing it under the levers, and bring it over the 15th degree of ♌ on the Ecliptic, † then mark with a pencil that part of the orbit of Mercury where the thread crosses it, and the mark will represent his place for the given day. Mark the orbits of Venus and the Earth in a similar manner; but as the Plate is not sufficiently extensive to admit the orbit of Mars, his place may be marked across the Ecliptic, which will answer the purpose sufficiently well.

After placing the Planets in their proper position over the preceding marks, you will observe, by looking from the Earth, that Mercury will have just passed his *greatest elongation,* and Venus will be fast approaching her *superior conjunction:* consequently their motions will be *direct.* These two Planets will then appear on the right hand or west of the Sun: hence, they will set before him in the evening, and rise before him in the morning. Mercury may be seen with a telescope in the morning twilight, near the eastern horizon; and Venus will appear as a *morning star.* Mars will be seen on the left hand or east of the Sun, and nearly in *opposition* to him; therefore he will rise before the Sun sets, and as he will be very near the Earth, he will make a large fiery red appearance in the eastern part of the Heavens.

Mercury and Venus, as seen from the Earth, will appear in different degrees of Libra ♎, which are called their *geocentric longitudes.* The geocentric longitudes of the Planets are given for every day, on the right hand page of every month in White's Ephemeris, and are used to find their places on the Celestial Globe (see page 80), or on the Maps accompanying this work.

If the Planets be removed from their positions, and the distance between the Earth's place and that of each Planet be taken with a pair of compasses, and applied to the scale at the bottom of the Plate, it will be found that the distance of Mercury from the Earth will be about 103 millions of miles, Venus about 155 millions of miles, and Mars about 62 millions of miles.

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* When the minutes are under 30, omit them; and when over 30, make the degrees one more.

† The Ecliptic is marked with a dash at every 15 degrees, and with a dot at every 5 degrees; the intermediate degrees may be estimated near enough by the eye.

Another very pleasing phenomenon may be represented by means of four little ivory balls or small white marbles, having one side painted black. They are to be placed on the orbits of the Earth and Planets, in their proper position, according to the above marks, with the white parts turned towards the Sun. The white part of the balls will then represent that side of the Planets which is enlightened by the Sun; and by looking from the Earth ball towards the others, you will find Mercury to be like a half-moon; while Venus and Mars will appear with nearly a full enlightened orb.

The phases of the Moon may also be represented for any given day, by placing the Earth ball in the centre of the plate, and substituting the orbit of Mercury for that of the Moon. Suppose, for example, it were required to represent the appearance of the Moon on the 18th of November, 1830. The Sun's place on that day will be in the 25th degree of ♏, and the Moon's place will be in the 28th degree of ♐;* therefore, place one of the balls on the Ecliptic, at the 25th degree of ♏, to represent the Sun. Fix a thread to the centre, as before, bring it over the 28th degree of ♐, and mark the orbit of Mercury where the thread crosses it. Place a ball on this mark, so that the white part is turned towards the Sun in the Ecliptic, which will represent the Moon. Place another ball on the centre, with the white part also towards the Sun, to represent the Earth; then, looking from the Earth ball towards the Moon ball, the latter will be found to appear in the shape of a beautiful thin crescent, a little on the left or east of the Sun: consequently she will be seen in that form in the western part of the Heavens soon after Sun-set.

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* The Sun's Longitude, commonly called the Sun's place, is given for every day, in the second column of the right-hand page of every month, in White's Ephemeris. The Moon's Longitude is also given in the adjoining column.

By looking from the Moon ball towards that of the Earth, you will find that the latter will appear to the former with nearly a full enlightened disc. See page 105. Thus may these curious and interesting phenomena be represented for any day in the year.

Inclination of the orbits of the Moon and Planets to the plane of the Ecliptic; Nodes, Latitude, &c.

The Moon and Planets do not move in the Ecliptic, but are seen during one half of their periodical revolution a little above or north of it; and during the other half, as much below or south of it: consequently their orbits are inclined to the plane of the Ecliptic, and cross it in two opposite points called their *nodes*.

Let the surface of the plate represent the plane of the Ecliptic, then the plain part of the orbits of the Moon, Mercury, and Venus will represent that half which is above, and the dotted part that half which is below, the plane of the Ecliptic; and the points between the plain and dotted parts, will be their nodes.

When the Moon or a Planet is in that part of its orbit which is above the plane of the Ecliptic, it is said to be in *north latitude*, and when it is in that part which is below the plane, it is in *south latitude*. The geocentric latitude of the Planets is given for every 6 days at the top of the right-hand pages of White's Ephemeris. That node in which the Moon or a Planet ascends from a southern to a northern latitude, is called the *ascending node*, and is denoted by the dragon's head ☊; the other is termed the *descending node*, and is characterized by the dragon's tail ☋.

The following table shews the inclinations of the Moon and Planets' orbits to the plane of the Ecliptic; and the places of their ascending nodes.

Planets.	Inclination of their orbits.		Place of ☊ Nodes.			Planets.	Inclination of their orbits.		Place of ☊ Nodes.		
	°	'	°		'		°	'	°		'
Mercury.	7	0	15	♉	21	Juno.	13	4	21	♌	6
Venus.	3	34	14	♊	26	Ceres.	10	38	21	♊	6
Earth.	—	—	—		—	Pallas.	34	51	22	♍	29
Moon.	5	9	Variable.			Jupiter.	1	19	7	♋	56
Mars.	1	51	17	♉	39	Saturn.	2	30	21	♋	32
Vesta.	7	9	13	♋	1	Herschel.	0	46	12	♊	47

Hence it appears, that Juno, Ceres, and Pallas, are sometimes seen beyond the limits of the Zodiac, which extends to only 8 or 10 degrees on each side of the Ecliptic. The nodes of the Planets' orbits do not always keep in the same point; but move retrograde a few seconds every year; and those of the Moon shift back about 19° 19' 44" every year at a mean rate, so as to make a complete revolution in about 18 years, 228 days, 6 hours.

ECLIPSES.

The Planets and Satellites, being opaque bodies and illuminated by the Sun, cast a shadow behind them, which terminates in a point at a greater or less distance, according to the size and distance of the Planet by which the shadow is projected.

When a Satellite passes through the shadow of its primary, it cannot be seen for want of light, and is said to be *eclipsed;* and when the shadow of a Satellite passes over the surface of its primary, it intercepts the Sun's rays, and conceals him from the view of its inhabitants: though it is the primary Planet itself that is really eclipsed.

The shadow of the Earth and Moon are represented in Fig. 12, PLATE IV. The dark shade is of a conical shape, in which no part of the Sun can be seen, and is termed the *umbra;* the light shade grows wider in proportion to its extent, in which a part of the Sun only can be seen, and is called the *penumbra.*

Eclipse of the Moon.

AN Eclipse of the Moon is occasioned by her passing through the Earth's umbra; consequently, it must occur at the time of *full moon,* or when she is in opposition to the Sun, as at M. The eclipse begins at *b* on the eastern limb of the Moon, and ends at *e* on her western limb. This may easily be conceived by supposing the Moon to move in its orbit from *p* through M to *a.*

If the Moon always moved in the plane of the Ecliptic, she would pass through the Earth's shadow and be eclipsed at every full; but it has already been observed (page 146.) that she is mostly seen above or below the Ecliptic: consequently, she generally passes either above or below the Earth's shadow. Thus, if the Moon be full at B, PLATE III., she will pass above the shadow; and if she be full at D, she will pass below it; but if she be full at A, in her node, she will pass through the shadow and be eclipsed.

When the Moon is full at about 12 degrees from either node, she just touches the shadow without entering it; when she is full between 6 and 12 degrees from either node, she is said to be *partially eclipsed,* because she does not enter wholly into the shadow. But when she is full within about 6 degrees of either node, she is *totally eclipsed;* and when full in the node, she passes through the centre of the shadow, and she is said to be *centrally eclipsed.* The duration of a central eclipse is from 3 to 4 hours, according to the distance of the Moon from the Earth at the time.

The Moon passes through the penumbra before she enters the umbra, which causes her gradually to grow dim before the eclipse begins; for the nearer she approaches the umbra, the less light she receives from the Sun.

The Moon, even when totally eclipsed, is not always invisible, if she be above the horizon and the sky clear, but appears generally of a tarnished copper colour. The cause of this phenomenon is attributed to the refraction of the Earth's atmosphere, which bends the scattered rays of the Sun into the umbra, so that the real dark shadow of the Earth terminates in a point before it reaches the Moon. See the figure. Some of these scattered rays falling on the Moon, give her the colour above mentioned.

The quantity of an eclipse is measured by digits; a digit being the twelfth part of the diameter of the Sun or Moon. If half the Moon enters the Earth's umbra, she is said to be eclipsed 6 digits, as at *a*, Fig. 13, Plate IV.; if her whole body just enters it, she is 12 digits eclipsed, as at *b*. She is sometimes said to be more than 12 digits eclipsed, all the digits therefore above 12, shew how far she is above or below the nearest edge of the shadow at the middle of the eclipse; hence, at *c* she is said to be eclipsed 18 digits, her upper limb being 6 digits below the edge of the shadow. An eclipse of the Moon is visible, and of the same quantity, and duration, to all parts of the Earth where she is above the horizon.

The circular shadow of the Earth upon the Moon, during an eclipse, is an evident proof of its sphericity; for no other form would, under all circumstances, cast such a shadow. The conical shape of the shadow also proves that the Earth is smaller than the Sun, for if they were both of one size, the shadow would be *cylindrical,* as in Fig. 14. If the Earth were larger than the Sun, the shadow would increase in breadth, as in Fig. 15; and in both cases it would extend to the orbits of the superior Planets, and eclipse them. But these Planets are never eclipsed by the shadow of the Earth; hence the Earth is neither equal to, nor larger than the Sun; consequently it must be smaller, and its shadow must terminate in a point short of the orbit of Mars.

Eclipse of the Sun.

An eclipse of the Sun is occasioned by the Moon, when she passes between the Sun and the Earth; her shadow falling on the Earth intercepts the Sun's ray from coming to those parts over which the shadow passes: hence, an eclipse of the Sun can occur only at the time of *new-moon,* or when she is in conjunction, as at *m,* Fig. 14, Plate IV.

Solar eclipses do not occur at every new-moon, for the same reason that Lunar eclipses do not occur at every full-moon; but when the Moon changes within 17 degrees of either node, an eclipse *may* occur; and when she changes within 15 degrees of either node, an eclipse *must* occur. Eclipses of the Sun are not visible to all parts of the Earth where he is above the horizon, because the Moon's penumbra *n n* is not large enough to cover the whole hemisphere.

As no part of the Sun can be seen within the *umbra,* all those places over which its point *o* passes, will have a *total eclipse;* and as only a part of the Sun can be seen within the *penumbra,* all those places covered by it, will have a *partial eclipse,* which will be greater or less as the places are nearer to or farther from *o,* the centre of the penumbra.

Now, as the Moon travels from *m* towards *p,* the shadow moves from *r* towards *s:* consequently, when the shadow reaches an observer at *s,* the eclipse begins, and at the same moment of absolute time to an observer at *r,* the eclipse ends; for to the former, the eastern limb of the Moon is just beginning to obscure the western limb of the Sun at *t,* and to the latter, the western limb of the Moon is just leaving the eastern limb of the Sun at *v.* To all places beyond the reach of the penumbra, the eclipse will be invisible.

The Moon revolves about the Earth in an elliptical orbit, having the latter situated in the lower focus; consequently, she is much nearer to us when at *p* in *perigee,* than when she is at *a* in *apogee.* When the Moon is at *m,* she is at her mean distance from the Earth, and the point *o* of her conical shadow just reaches the Earth; therefore, a total eclipse of the Sun continues only for a moment, when the Moon is at her mean distance from the Earth.

But as any part of the Moon's orbit may be turned towards the Sun, if the point *p* were at *m*, she would then be at her least distance from us, and the umbra at *o* would cover a space of about 180 miles broad. Hence, if the Moon then changes in her node, the total eclipse will be the longest possible, viz. about 4 minutes 6 seconds. If the point *a* were at *m*, the Moon would be at her greatest distance from us, and the point *o* of the *umbra* would not reach the Earth; therefore, the apparent diameter of the Moon would be much less than that of the Sun, so that he would appear all round the dark orb of the Moon, in the form of a *luminous ring*. This is termed an *annular eclipse*, one of which it is calculated will be visible in England in the year 1847. An eclipse of the Sun may continue annular about 12 minutes.

There cannot be less than two eclipses in a year, nor more than seven; but the most usual number is four, two solar and two lunar. There may be three of the Moon, and there may be none. If there be only two eclipses in a year, they will be of the Sun; and if five, three will be of the Sun and two of the Moon.

If to the mean time of any eclipse, either of the Sun or Moon, you add 18 Julian years, 11 days, 7 hours, 43 minutes, 20 seconds, when the last day of February in leap years comes in four times, or a day less when it comes in five times, you will then have the mean time of the return of the same eclipse.

The Satellites or Moons of Jupiter, Saturn, and Herschel, are eclipsed, and cause eclipses of the Sun to those Planets in a manner similar to those we experience; but they are much more frequent with them than with us, because they have a greater number of Moons. Those of Jupiter's Satellites are calculated to a second of time, and are exceedingly useful in ascertaining the longitude of places.—See p. 115.

Eclipses, like Comets, were formerly beheld with terror and amazement; but they are now looked upon as one of the most sublime of all natural phenomena, which never fail to excite and gratify the curiosity of all ranks and ages.

MILITARY ORRERY,

OR A

NEW ASTRONOMICAL GAME.

Provide eight ivory or wooden balls of different sizes from two to three inches in diameter, to represent the Planets, having one side painted black and the other white, with a piece of wire thrust into each, as shewn in Fig. 17, Plate IV. Write the characters of the Moon and Planets on each respectively, taking the least ball for the Moon, and the others according to the magnitudes of the Planets. Then take nine blank cards, on which write the particulars of the Sun and Planets as follow:

☉
The Sun.
Distance, 95,000,000 miles.
Cannon ball, 23 years.
Diurnal rotation, 25½ days.
Diameter, 886,000 miles.
Magnitude, 1,405,000 times.

☿
Mercury.
Distance, 37,000,000 miles.
Cannon ball, 9 years.
Annual revolution, 3 mo. 4 days.
Rate, 110,000 miles per hour.
Diurnal rotation, unknown.
Diameter, 3108 miles.
Magnitude, one sixteenth.

♀
Venus.
Distance, 69,000,000 miles.
Cannon ball, 16½ years.
Annual revolution, 8 mo. 1 day.
Rate, 80,000 miles per hour.
Diurnal rotation, 23 hrs. 20 min.
Diameter, 7498 miles.
Magnitude, nearly one.

○'
⊕ *The Earth.*
Distance, 95,000,000 miles.
Cannon ball, 23 years.
Annual revolution, 365¼ days.
Rate, 68,000 miles per hour.
Diurnal rotation, 24 hours.
Diameter, 7912 miles.
Magnitude, one.
Moons, one.

☽
The Moon.
Distance from the Earth, 237,000 miles.
Cannon ball, 3 weeks.
Synodical revolution, 29½ days.
Rate, 2270 miles per hour.
Diurnal rotation, 29½ days.
Diameter, 2144 miles.
Magnitude, one fiftieth.

♂
Mars.
Distance, 145,000,000 miles.
Cannon ball, 34½ years.
Annual revolution, 1yr. 11mo. 14d.
Rate, 55,000 miles per hour.
Diurnal rotation, 24 hrs. 40 min.
Diameter, 4218 miles.
Magnitude, one seventh.

· ·○· · ♃ *Jupiter.*	· · ·○· · · · ♄ *Saturn.*	· · ·○· · · ♅ *Herschel.*
Distance, 495,000,000 miles.	Distance, 907,000,000 miles.	Distance, 1,822,000,000 miles.
Cannon ball, 118 years.	Cannon ball, 215½ years.	Cannon ball, 433 years.
Annual revolution, 12 years.	Annual revolution, 29½ years.	Annual revolution, 83½ years.
Rate, 30,000 miles per hour.	Rate, 22,000 miles per hour.	Rate, 15,000 miles per hour.
Diurnal rotation, 9¼ hours.	Diurnal rotation, 10¼ hours.	Diurnal rotation, unknown.
Diameter, 89,069 miles.	Diameter, 78,730 miles.	Diameter, 35,112 miles.
Magnitude, 1400 times.	Magnitude, 985 times.	Magnitude, 88 times.
Moons, four.	Moons, seven, and two rings.	Moons, six.

Take twelve more cards, on which draw the figures and characters of the Zodiacal Constellations; and write on each the time of the Sun's entrance into them, according to the following table:

Spring Signs.

♈ Aries, *the Ram*, March 20th.
♉ Taurus, *the Bull*, April 20th.
♊ Gemini, *the Twins*, May 21st.

Summer Signs.

♋ Cancer, *the Crab*, June 21st.
♌ Leo, *the Lion*, July 23d.
♍ Virgo, *the Virgin*, August 23d.

Autumnal Signs.

♎ Libra, *the Balance*, September 23d.
♏ Scorpio, *the Scorpion*, October 23d.
♐ Sagittarius, *the Archer*, November 22d.

Winter Signs.

♑ Capricornus, *the Goat*, December 22d.
♒ Aquarius, *the Waterman*, January 20th.
♓ Pisces, *the Fishes*, February 19th.

Having prepared the cards, make a mark in the middle of the room for the Sun's place: then tie a loop at one end of a cord and a knot at the several distances of 2 feet, 3½, 5, 7½, 26, 47½, and 95 feet, which are the proportional distances of the Planets in order from the Sun. With these several distances describe as many circles round the Sun's place, as the extent of the room will admit, for the orbits of the Planets. Place the above mentioned twelve cards round and a little beyond the outer orbit, at an equal distance from each other, and in the same order as shewn in PLATE III., which will represent the signs of the Zodiac.

This being done, let a president be chosen, who should stand in the centre to represent the Sun, and to conduct the game. Place a pupil on each orbit, with a ball and card to represent Mercury, Venus, the Earth, the Moon, and Mars,* each being considered as an inhabitant of the Planet which he represents, and to be called by its name.

The president should then interrogate the pupils on the contents of the cards, putting a question to each in rotation, and always beginning with Mercury, the nearest Planet to the Sun. The following may serve as an example :

Quest. What Planet do you represent? *Ans.* Mercury. *Q.* What distance is Mercury from the Sun? *A.* 37 millions of miles. *Q.* How long would it take a cannon ball, flying at the rate of 480 miles per hour, in travelling thence to Mercury? *A.* 9 years. *Q.* What is the length of Mercury's year? *A.* 3 months, 4 days, being the time in which he makes a complete revolution round the Sun. *Q.* At what rate does he move in his orbit? *A.* 110 thousand miles per hour. *Q.* What is the length of his day, or the time in which he revolves on his own axis? *A.* That has not yet been discovered. *Q.* What is the length of Mercury's diameter? *A.* 3108 miles. *Q.* What is his magnitude compared with that of the Earth? *A.* He is only one sixteenth part of the size of the Earth. *Q.* Has Mercury any Moons or Satellites? *A.* No.

The president should repeat the contents of his own card in his turn, and cause his pupils to forfeit a counter to any one who may remind him of a mistake, for this purpose they should have a dozen counters dealt out to each.

After a little exercise in the preceding game, the president may put his Orrery in motion. In order to do this he should provide a musician, to play a slow march. The pupils should hold the balls so that the white parts may continue to be directed towards the Sun ; and at the word of command, the music should begin to play, and the pupils to march round their respective orbits, in the order of the signs.

The length of their steps should be so regulated, that while the

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* These are all the Planets that can be conveniently exhibited in a room at one time ; but on a play ground the whole may be introduced, and the Zodiacal cards may be erected on sticks.

Earth makes one revolution, Mercury may make three, and Venus one and a half; but Mars should get only half way round, Jupiter the length of one sign, Saturn about one third of a sign, and Herschel about one seventh part of a sign. The Moon should march round the Earth twelve times, or once while the Earth moves from one sign to another.

At the end of every revolution of the Earth, the president should command them to *halt*, when each pupil should hold his ball over the place where he stops, so that it may be seen by the others. The president should then question each pupil as to what sign his Planet is in, and in what sign the Sun, and the other Planets appear, together with the phases they exhibit as seen from his Planet.

Fines should be imposed in this, as in the former part of the game; and at the conclusion, he who has the most counters should be appointed president when the game is resumed.

After the pupils have become expert in answering the questions on the cards, others may be proposed, and extended to all the phenomena detailed in the Solar System, till the whole be perfectly known.

TELESCOPIC

APPEARANCE OF THE UNIVERSE.

THE knowledge of the ancients was confined to those stars which are visible to the unassisted eye, the number of which in both hemispheres, according to some authorities, does not exceed 3500; but since the invention of telescopes, a new and extensive field has been opened for the speculations of the contemplative mind.

By the powerful aid of telescopes, myriads of stars have been discovered, which were before invisible to us; and myriads more are brought into view, as the powers of those instruments are increased, so that the number of stars and the extent of the Universe may be said to be infinite. Those stars which cannot be seen without a telescope are called *telescopic stars.*

Several stars which are mentioned by ancient astronomers are now no longer visible, and new ones have appeared in different parts of the Heavens which are not recorded in their catalogues; some of these have also finally disappeared. Dr. Herschel mentions 13 of this kind.

The principal telescopic objects beyond the Solar System, are Variable Stars, Double Stars, and Nebulæ.

Variable Stars are such as undergo periodical variations in their apparent magnitudes, of which the star Algol in Medusa's Head is the most remarkable; its period being about 2 days 21 hours. It gradually varies, in the space of nearly 4 hours, from the second to the fourth magnitude, and recovers its greatest lustre in the succeeding 4 hours, which it retains to the end of its period.

The number of Stars which have been ascertained to be variable, amounts to 15 only; while those which are suspected to be so amount to 37.

The cause of these variations has been attributed to large black spots on their surfaces, which, during the diurnal rotation of the Stars, produce a gradual change in their brilliancy.

Double Stars are those which appear single to the naked eye, but when seen through a telescope are found to consist of two, three, or more: hence they are termed double, treble, quadruple, &c. Dr. Herschel has formed a catalogue of 269 double Stars, only 39 of which are visible to the unassisted eye; and out of this number he has found, by a series of observations, that many of them have changed their situation with respect to each other;—that the one performs a revolution round the other, or both round a common centre of gravity, and that the motion of some is direct, while that of others is retrograde. These he terms *binary sidereal systems.*

The observations which have been published relate to the following six *binary sidereal systems* only.

Char.	*Names.*	*Mag.*	*Situation.*	*Colour of each Star.*	*Period of smaller round the larger Star.*
α	Castor.	1	Head of Castor.	Both white.	342 years 2 months.
γ	Gamma Leonis.	2	Neck of Leo Major.	L. White. S. Reddish white.	1200 years.
ε	Mirach.	3	Girdle of Bootes.	L. Light red. S. Fine blue.	1681 years.
ζ	Zeta Herculis.	3	Back of Hercules.	L. Bluish white. S. Fine ash.	S. Nearly occulted by L. April 11th, 1803.
δ	Delta Serpentis.	3	Neck of Serpens.	L. White. S. Greyish.	375 years.
γ	Gamma Virginis.	3	Left wing of Virgo.	Both white.	708 years.

Those which do not revolve are supposed to consist of two or more Stars at different distances beyond each other.

The following are also included in the number of double Stars, viz. The Pole Star, Betelguex, Rigel, Capella, Aldebaran, Altair, Regulus, Alphirk, Alpheratz, Almaach, Ras Algethi, and Vega. Pollux is a multiple Star.

Nebulæ are luminous spots in the Heavens of a misty or cloudy appearance, most of which, when viewed with a powerful telescope, are found to consist of a vast collection of minute Stars.

A beautiful milky nebula containing seven small Stars, appears near the middle Star of Orion's sword; the nebulosity of which varies in shape, and is not resolvable into Stars. Huygens, who discovered this beautiful phenomenon, says, that in viewing it, he saw as it were, through an opening, *into a region of light!*

Dr. Herschel has given a catalogue of 2500 nebulæ, some of which consist of one, two, or more stars surrounded with nebulosity; others of clusters of Stars; some of masses of Stars; and others of luminous matter only. They are to be found in almost every constellation, and appear in every variety of shape.

The Via Lactea, or Milky Way, is considered as forming one great nebula, encircling the Heavens in the form of a luminous zone, which Dr. Herschel found to consist of a continued assemblage of smaller nebulæ.

In order to account for the appearance of this singular phenomenon, Dr. Herschel supposed our Sun to be placed in the inside of it, but not exactly in the centre of its thickness. The Milky Way, therefore, according to this supposition, is the projection of the nebula upon the apparent concave surface of the Heavens, as seen from a point within it.

There are many other nebulæ in the Heavens as large as that of the Milky Way, which, for a like reason, may exhibit the phenomenon of a luminous zone to the planetary worlds that are probably placed within them, as the Milky Way does to us.

Those Stars that do not form *binary sidereal systems,* Dr. Herschel supposed to be so remote from others, as to be in a great measure beyond the reach of the attractive power of other Stars, such as our Sun, Sirius, Vega, Arcturus, Capella, and many others, which he has termed *insulated Stars.* These only were considered by that great astronomer to be the centres of extensive planetary systems like our own. Therefore, instead of supposing that every Star in the Universe is encircled with Planets, Satellites, and Comets, as has generally been done; Dr. Herschel believed that the *insulated Stars* alone are surrounded with such attendants.

GENERAL DESCRIPTION

AND

USE OF THE MAPS.

By the first three Problems on the Celestial Globe (pages 63—74) it will be found, that the aspects and phenomena of the Starry Heavens are not alike in every part of the world. For, to the Equatorial inhabitants, the whole of the Stars rise and set, perpendicularly to the horizon, in the course of the 24 hours; but to the Polar inhabitants, one half of the Heavens are never visible, and the Stars in the other half appear to be continually circulating about the pole, parallel to the horizon, without setting; while the inhabitants between the Equator and the Poles, see more or less stars, the nearer they approach to, or recede from, the Equator. Hence, to all places remote from the Equator, in either hemisphere, there is a certain portion of the Stars about the elevated pole which never set, and a like portion about the depressed pole which never rise to them. See Problem IV. page 75.

The Maps consist of entire views of all those Stars, as they appear to the naked eye, which are visible in the parallel of London, from the first to the fourth magnitude; with the boundaries of each Constellation accurately defined.

The centre of the Maps represents the *zenith*, or that point of the Heavens which is over the observer's head; and the outer circles the *horizon*, on which is engraved the names of its principal points. The line N S represents the *meridian of the place of observation;* and E W the *prime vertical* circle, intersecting the meridian in the zenith, and cutting the horizon in the *east* and *west* points. The small circle on the upper part of each Map is the circle of *perpetual apparition,* all the Stars within which, never set in the latitude of London. See page 71.

The plain curved line drawn downwards from E to W, is the *Equinoctial line.* The space included by the three dotted curves, is the *Zodiac,* which is divided into the several signs by dotted lines, and distinguished by their proper characters; the middle line of the three being the *Ecliptic.*

Stars of the first magnitude are expressed by an asterisk of eight points; those of the second, by seven points; the third, by six points; the fourth, by five points; and the fifth magnitude, by an asterisk of four points.

The names of the Constellations are distinguished from those of the Stars, by capitals; and they are all engraved in a circular form, for the convenience of reading during the time of observation.

The Moon and Planets may be laid down on the Maps, in pencil, for any given day, and their apparent paths among the Stars delineated in a manner similar to that shewn in Problem XI. page 82. Suppose, for example, I wish to represent the position of the Moon, and those Planets which are visible in the evening of the 21st of December 1830. By referring to the right-hand page of the month in White's Ephemeris, or pages 4th and 5th of the Nautical Almanac, I find that the Moon's longitude at noon* will be 11° ♓ 3′, and her latitude 0° 43′ S; therefore her place will be near a Star on the Ecliptic of the fourth magnitude, in that sign. The longitude of Mars will be 10° ♈ 35′, and his latitude 0° 9′ N.; his place, therefore, will be near the western Star of the three forming a line, of the fourth magnitude in the sign ♈ Aries. Mercury will be in 9° ♑ 10′, Venus in 39° ♐ 27′, Jupiter in 22° ♑ 47′, Saturn in 1° ♏ 45′, and Herschel will be in 8° ♒ 45′: consequently none of their places fall within the signs contained in the Map for December.

If the position of the Moon be accurately laid down, according to her latitude and longitude for every noon and midnight during her lunation, on the Map for the given month, and on those immediately preceding and following it; the latter will then be a sure guide to those persons who determine the longitude by Lunar Observations; for the relative position between the Moon and those Stars from which the lunar distances are taken, will be clearly ascertained thereby.

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* The Moon's longitude should be reduced to the time of observation, by the rule given in the note at the bottom of page 80, if greater accuracy be required.

The following table contains the names, &c. of the Stars used in determining the longitude by Lunar Observations, which may be found on the Maps, either in or near the Zodiac.

Names used in the Nautical Almanac.	*Names, &c. as expressed on the Maps.*		
	Mag.	*Names.*	*Constellations.*
Arietis.	2	Arietis.	Aries.
Aldebaran.	1	Aldebaran.	Taurus.
Pollux.	2	Pollux.	Gemini.
Regulus.	1	Regulus.	Leo Major.
Spica.	1	Spica Virginis.	Virgo.
Antares.	1	Antares.	Scorpio.
Aquilæ.	1	Altair.	Aquila.
Fomalhaut.	1	Fomalhaut.	Pisces Australis.
Pegasi.	2	Markab.	Pegasus.

The altitude of the Moon, of a Planet, or of any Star, may be found by taking the distance, with a pair of compasses, between its place and the nearest part of the horizon; that extent being applied to the scale at the bottom of the Map for December, will give its altitude in degrees.

To enable students, who are not in possession of a quadrant, to take the altitude of any object in the Heavens, I shall here instruct him how to make one. See Fig. 16. Plate IV. Take a piece of thick Bristol board, about six inches (perfectly) square;—draw lines along two adjacent sides, about the eighth of an inch from the edges, for the lines *a c* and *a b*;—then, setting one foot of your compasses on the point *a*, where the lines intersect, describe as large an arc *b c* as the board will admit. Divide the arc *b c* into nine equal parts, each of which subdivide into ten equal parts for degrees, and number them as in the figure. Make a paper tube about half an inch in diameter, and fix it along the side *a c* parallel to the edge of the quadrant. The tube should be nearly closed at *c*, leaving only a small aperture in the centre of it; and two threads should be placed across the end *a*, intersecting each other in the centre. Fix a plumb-line *a d* to the point *a*, and the Quadrant will be completed.

To observe the altitude of a Star, suppose for instance, the *North Pole Star s*, hold the Quadrant in a vertical position, and directing the tube towards the Star, so that by looking through the aperture at *c*, you may bring it exactly on the crossing of the threads; then, the degree on the arc *b c* which is cut by the plumb-line will be its altitude in degrees. For the arc A B of the Heavens is equal to the arc *b c* of the quadrant.

The altitude of the *North Pole Star* is equal, or nearly so, to the latitude of the place of observation; consequently, if the observer be at London, its altitude will be about 51½ degrees.

If the altitude of the Sun be observed, the eye must be protected by a piece of smoked or coloured glass, placed before the aperture of the tube.

A table of the times of observation is given at the head of each Map, for every fifth day. Thus, on the 1st of January, the Map for that month will represent a complete view of the Starry Heavens at 9 o'clock in the evening; on the 6th at 40 minutes after 8; and on the 11th at 20 minutes after 8 o'clock. If four minutes earlier be allowed for every night after those given in the table, it will give the time of observation for every night in the year; or, if the time be taken for the nearest day in the table, it will be sufficient for common practice.

Although the several Maps will represent the appearance of the Starry Heavens, only at one hour of the same night, as given at the head of each; yet different Maps will be found to answer the same purpose for different hours of the night, according to the following table, which is constructed on the principles illustrated in page 134, viz. that the Stars culminate about two hours earlier every night. Thus, for instance, the Map with its description for December, may be used if the time of observation be 2 hours earlier; that for February, if 2 hours later; that for March, if 4½ hours later; that for April, if 6½ hours later; and the Map, &c. for May, if the time be 9 hours later than that given for the several days at the head of the Map for January.

Given Month.	*Hours Earlier.*	*Map to be used.*	*Hours Later.*	*Map to be used.*	*Hours Later.*	*Map to be used.*	*Hours Later.*	*Map to be used.*	*Hours Later.*	*Map to be used.*
January.	2	December.	2	February.	4½	March.	6½	April.	9	May.
February.	2	January.	2½	March.	4½	April.	7	May.	10	June.
March.	2½	February.	2	April.	4½	May.	7½	June.	9½	July.
April.	2	March.	2½	May.	5½	June.	7½	July.	8½	August.
May.	2½	April.	3	June.	5	July.	6	August.	7½	September.
June.	3	May.	2	July.	3	August.	4½	September.	6½	October.
July.	2	June.	1	August.	2½	September.	4½	October.	6	November.
August.	1	July.	1½	September.	3½	October.	5	November.	7	December.
September.	1½	August.	2	October.	3½	November.	5½	December.	7½	January.
October.	2	September.	1½	November.	3½	December.	5½	January.	7½	February.
November.	1½	October.	2	December.	4	January.	6	February.	8½	March.
December.	2	November.	2	January.	4	February.	6½	March.	8½	April.

The Maps should be held, during the time of observation, in a vertical position before you, with that point of the horizon downwards towards which you are turning your attention. If, for instance, you are looking at the Stars in the south, hold the S. point of the horizon downwards; if to those in the north, hold the N. point of the Map downwards; and so on for the eastern, western, or any other aspect.

MONTHLY OBSERVATIONS

ON THE

PERIODICAL SITUATIONS OF THE CONSTELLATIONS, AND PRINCIPAL STARS.

JANUARY.

THE Heavens, during the evenings of this month, invitingly claim the attention of the student, by the splendid appearance of the most beautiful Constellations in the Universe. They are chiefly situated in the S. E. quarter, where eight Stars of the first magnitude are presented to his view.

ORION in the S. S. E. *Betelguex* (18),* *Bellatrix* (15), *Rigel* (13), and *Saiph* form a large trapezium, or a figure of four unequal sides, the three Stars which form his *Belt* being in the middle of it.

An imaginary line passing through the three Stars in the BELT of ORION, directs the student's eye down to *Sirius* (20), or the Dog Star, in the mouth of CANIS MAJOR. It is of the first magnitude, and the most beautiful Star in the Heavens.

Procyon (24), in CANIS MINOR, is E. of ORION, and nearly at the same height as Rigel, these two stars, with Sirius, form a large triangle.

Aldebaran (11), in TAURUS, is near the meridian, and about 53 degrees high.

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* These numbers correspond with those prefixed to the Stars used by Mr. T. Lynn, in his "Star Tables," for determining the Latitude and Longitude, by Stellar observations.

The names of the Constellations are printed in capitals, and those of the Stars in small italics, as on the Maps.

If a line were drawn through the three Stars in the *Sword* of Orion, it would pass W. of Aldebaran, and direct the eye up to the *Pleiades*. LEO MAJOR is rising in the E. *Regulus* (31), its principal Star, being about 8 degrees above the horizon.

Capella (12), a beautiful Star of the first magnitude in AURIGA, is about 13 degrees E. S. E. of the zenith.

Castor (23) and *Pollux* (25), in GEMINI, are nearly in a line with Rigel and Betelguex, in Orion.

CETUS occupies a large space between the S. and S. W. Its principal Star is *Mencar* (8), of the second magnitude, which, with two other Stars of the third magnitude, in the head, form a small triangle.

ERIDANUS is on the meridian.

Markab (59), in PEGASUS, is about 22 degrees above the western horizon, and forms a large triangle with *Scheat* (58) and *Algenib* (1), in the same Constellation.

A line supposed to be drawn from Markab to the zenith, will pass *Alpheratz* (60), in the head, *Mirach* (4), in the girdle, and *Almaach*, in the right foot, of ANDROMEDA.

Algenib (10), in PERSEUS, is near the zenith; and *Algol* (9), is about 9 degrees S. S. W. of the former.

The seven principal Stars in URSA MAJOR, may be seen in the N. N. E. *Dubhe* (33) and *Merak* (32), are called the *Pointers*, because a line passing through them points nearly to the *North Pole Star* (0), in the tail of URSA MINOR.

Cor Coroli is in the N. E. by N. about 9 degrees high.

DELPHINUS and VULPECULA ET ANSER will take their leave of us in the W. at the end of this month; and will not be seen again in the evening till the middle of May, when they will re-appear in the E. N. E. The MILKY WAY may be seen, if the sky be clear, extending from the S. E. through the zenith, to the N. W. part of the horizon.

FEBRUARY.

Regulus (31), in the heart, and *Denebola* (34), in the tail, of LEO MAJOR, are of the first magnitude; and may be seen in the E. the former 29, and the latter 15, degrees high.

Procyon (24), in CANIS MINOR, may be known by its being accompanied by a Star of the third magnitude. They are in the S. S. W. about 40 degrees high.

An imaginary line drawn through the two Stars in Canis Minor, will pass up through the four Stars in the feet of GEMINI.

Sirius (20), in CANIS MAJOR, is approaching the meridian; displaying the greatest power of its brilliancy, at the height of 20 degrees.

In the S. E. is *Cor Hydræ* (30), and nearly in a line between Regulus and Procyon, are four or five Stars, in the head of HYDRA.

Betelguex (18), in the right shoulder of ORION, has just passed the meridian. The beauty of this Constellation is not equalled by any other in the Heavens.

CETUS is declining towards the W. S. W. part of the horizon. *Mencar* (8), its principal Star in the head, is about 28 degrees high.

A line supposed to be drawn from *Rigel* (13), in ORION, through *Baten Kaitos*, in the body of CETUS, will pass near the principal Stars that are visible in ERIDANUS.

ARIES, the first Constellation in the Zodiac, is in the W. *Arietis* (6), its principal Star, is 35 degrees above the horizon; and may be known by two others of the third and fourth magnitudes, forming a small oblique triangle.

Aldebaran (11), in TAURUS, is nearly S. W. and at the height of 49 degrees.

Algenib (10), in PERSEUS, is 63 degrees high, W. S. W.; and below it is *Almaach*, *Mirach* (4), and *Alpheratz* (60), in ANDROMEDA.

The five Stars which form the fancied outline of the W. in CASSIOPEIA, are in the N. W. from 43 to 50 degrees high.

Vega (52), in LYRA, is too near the northern horizon to be seen.

Capella (12), in AURIGA, is about 11 degrees W. of the zenith; and a Star of the second magnitude in his right shoulder has just passed the meridian, near the zenith.

URSA MAJOR is in the N. E. *Benetnasch* (39), in the tip of his tail, is 26 degrees, and *Dubhe* (33), one of the *Pointers*, is 51 degrees high.

Rastaban, *Grumium*, and *Etamin* (51), in the head of DRACO, have just passed the meridian below the pole; thence they will take a circular route eastward towards the zenith.

Markab (59), in PEGASUS, is setting in the W. S. W.; but *Scheat* (58) and *Algenib* (1) are still visible, the former 10, and the latter 9 degrees above the horizon. At the close of this month, Pegasus will disappear in the W. and will not be seen again in evening, till June, when he will reappear in the E.

If the evenings be clear, and the Moon below the horizon, the MILKY WAY may be traced from the S. S. E. through Perseus, to the N. N. W. part of the horizon.

MARCH.

Arcturus (42), a beautiful Star of the first magnitude in BOÖTES, is in the E. about 17 degrees high.

URSA MAJOR appears in the N. E. *Dubhe* (33), its principal Star, is 67 degrees high.

Denebola, (34), in the tail of LEO MAJOR, is nearly E. S. E.; and *Regulus* (31), in the heart, is on the W. of it; the altitude of the former being 37 degrees, and that of the latter about 46 degrees.

A line supposed to be drawn from Denebola to *Benetnasch* (39), in the tail of URSA MAJOR, will pass through COMA BERENICES, and *Cor Coroli*, in CANES VENATICI.

About midway between Regulus, and Dubhe, are the five Stars in the body of LEO MINOR.

The beautiful Constellation of ORION, is in the S. W. A line supposed to be drawn through *Rigel* (13) and *Betelguex* (18), will be nearly perpendicular to the horizon, directing the eye up to *Castor* (23) and *Pollux* (25), in GEMINI.

Aldebaran (11), in the eye of TAURUS, is on the W. of Betelguex, and *Procyon* (24), in CANIS MINOR, is on the E. of it.

Sirius (20), in CANIS MAJOR, with Betelguex, and Procyon, form a large triangle.

Capella (12) in AURIGA, is nearly W., its altitude being about 57 degrees.

An imaginary line drawn from Capella towards the N. W. will pass *Algenib* (10), in PERSEUS, directing the eye to *Almaach*, in the right foot, and *Mirach* (4), in the girdle of ANDROMEDA.

The five Stars in CASSIOPEIA, are N. W. by N. from 28 to 40 degrees high.

Mencar (8), in CETUS, and *Arietis* (6), in ARIES, are about to disappear in the W.; and will not be seen again in the evening, till the beginning of September.

The MILKY WAY may be seen, if the sky be clear, crossing the western part of the Heavens; extending from N. to S.

APRIL.

The beautiful double Star *Vega* (52), in LYRA, is N. E. about 18 degrees high; and above it are three Stars called *Etamin* (51), *Rastaban*, and *Grumium*, which form a small triangle in the head of DRACO.

HERCULES is in the E. N. E. *Ras Algethi* (49), in his head, being just above the horizon.

Spica Virginis (38), in VIRGO, is in the S. E. about 17 degrees high.

Regulus (31), a double Star in LEO MAJOR, is near the meridian, 51 degrees high; and on the E. of it, is *Denebola* (34), about the same height. A line passing through these two Stars, will point out the situation of *Procyon* (24), in CANIS MINOR, on the W., and of *Arcturus* (42), in BOÖTES, on the E.

Spica, Denebola, and Arcturus form a large triangle.

URSA MAJOR is approaching the zenith, having the three Stars in his tail, extending towards the E.

Castor (23) and *Pollux* (25), in GEMINI, are W. S. W. about 52 degrees high.

If a line were drawn from Castor towards the N. N. W. it would pass *Capella* (12), in AURIGA, and *Algenib* (10), in PERSEUS.

Almaach, in the right foot of ANDROMEDA, and *Algol* (9), in PERSEUS, with Algenib, in the same Constellation, form a triangle, the latter being in the upper angle.

CASSIOPEIA is in the N. N. W. *Schedir*, the lowest Star, being elevated about 20 degrees above the horizon.

ORION is setting in the W. by S., the three Stars, in the *Belt*, being about 9 degrees high; and above them are *Betelguex* (18) and *Bellatrix* (15).

On the S. of Orion, is *Sirius* (20), in CANIS MAJOR, very near the horizon; and on the W. of him, is *Aldebaran* (11), in TAURUS, about 13 degrees high. The three last-mentioned Constellations will not be visible in the evenings after this month. Orion will re-appear, in the evening, about the middle of November, in the E.; and Canis Major about the beginning of January, in the S. E.

The MILKY WAY may still be seen, on a very clear evening, almost parallel to, and about 30 degrees above, the western horizon.

MAY.

The seven principal Stars in URSA MAJOR, commonly known by the names of Charles's Wain, or the Plough and Horses, &c., are in the zenith. About 18 degrees S. of *Alioth*, which is in the root of the Bear's tail, is *Cor Coroli*, in CANES VENATICI.

Arcturus (42), in BOÖTES, is nearly S. E., 53 degrees high; and E. of it, is *Gemma* (46), in CORONA BOREALIS.

Below Corona Borealis, are six bright Stars, in SERPENS, one of which is *Alpha Serpentis* (47), of the second magnitude, situated between two others of the third magnitude.

VIRGO is on the meridian, *Spica Virginis* (38), being S. by E. 27 degrees high.

LIBRA is on the E. of Spica Virginis; the altitude of its principal Star (44), on the Ecliptic, being about 17 degrees; and that of the next to it in brightness (45), in the northern scale, is about 21 degrees.

Ras Alhagus (50), in the head of SERPENTARIUS, is due E. 20 degrees high; and 5 degrees above it, bearing a little towards the S. is *Ras Algethi* (49), in the head of HERCULES.

Vega (52), in LYRA, is 29 degrees high, in the E. N. E. This Star may always be known by its being accompanied by two others of the third magnitude, just below it. The middle one is a *Quadruple-Star.*

Deneb (55), in CYGNUS, is in the N. E. 18 degrees high.

Above Lyra and Cygnus, is DRACO, extending to the meridian, N. of the zenith.

CASSIOPEIA is on the meridian below the Pole, being always on the opposite side of the *Pole Star* (0), to that of Ursa Major.

Denebola (34), in the tail of LEO MAJOR, is 52 degrees high, in the S. S. W.; and *Regulus* (31), in his heart, is about S. W. 40 degrees above the horizon.

HYDRA extends from W. S. W. to S. S. E. nearly parallel to the horizon. *Cor Hydræ* (30), in its heart, is 23 degrees below Regulus.

GEMINI is due W. *Castor* (23) and *Pollux* (25), being about 32 degrees high.

Capella (12), in AURIGA, appears in the N. W., and its altitude is about 23 degrees.

PERSEUS is between Auriga and Cassiopeia, *Algenib* (10), its principal Star, being N. N. W. 16 degrees above the horizon.

Procyon (24), in CANIS MINOR, and its little companion, are setting in the W. They will not be seen in the evenings, after this month, till January, when they will re-appear in the E.

The MILKY WAY extends from the E. through Cygnus, Cassiopeia, Perseus, and the feet of Auriga, to the W. In the N. its altitude is 20 degrees.

JUNE.

Delphinus is very conspicuous in the E. about 22 degrees high; and below it are the four small Stars in Equuleus.

Altair (53), in Aquila, is E. S. E., 25 degrees high. This Star may always be known by its being situated between two others of the third magnitude.

A line passing through the three last-mentioned Stars, will direct the eye up to *Vega* (52), in Lyra; and thence to *Etamin* (51), *Grumium*, and *Rastaban*, in the head of Draco.

Pegasus is rising in the E. N. E. *Scheat* (58), one of its principal Stars, being about 11 degrees high.

Andromeda is N. N. E. very near the horizon; and above her, are Cassiopeia and Cepheus.

Ras Alhagus (50), in the head of Serpentarius, and *Ras Algethi* (49), in the head of Hercules, are S. E. by S. their mean altitude being about 48 degrees.

A line supposed to be drawn from the zenith through the head of Draco, will direct the eye to *Deneb* (55), in the tail of Cygnus.

Gemma (46), in Corona Borealis, is nearly on the meridian, 66 degrees high; and below it are the principal Stars in Serpens.

Antares (48), in Scorpio, makes a transitory appearance in the S. by E., only 11 degrees high.

Libra has just passed the meridian, the altitude of its principal Star (44), on the Ecliptic, being 21 degrees.

Spica Virginis (38), in Virgo, is nearly S. W. about 20 degrees above the horizon.

An imaginary line drawn from Spica Virginis to the zenith will pass through *Arcturus* (42), in Boötes.

Regulus (31), in Leo Mojor, is setting in the W. and *Denebola* (34), in his tail, is W. by S. 29 degrees high. Denebola, Spica Virginis, and Arcturus, form a large triangle.

Above Denebola, are Coma Berenices, and Canes Venatici.

URSA MAJOR is N. W. of the zenith, *Dubhe* (33), the upper *Pointer*, being 51 degrees high; and URSA MINOR is on the meridian N. of the zenith.

AURIGA is scarcely visible in the N.

Castor (23) and *Pollux* (25), in GEMINI, are setting in the N. W. They will continue visible during the evenings of this month; after which they will disappear till November, when they will re-appear in the N. E.

The MILKY WAY may be traced, on a clear evening, from the S. through Cygnus, in the E. to the N. point of the horizon.

JULY.

ANDROMEDA extends from E. N. E. to N. E. having PEGASUS on the E. and PERSEUS on the N. Below her are PISCES and TRIANGULUM; and above her are CASSIOPEIA and CEPHEUS.

Markab (59), *Scheat* (58), and *Algenib* (1), in PEGASUS, with *Alpheratz* (60), in the head of ANDROMEDA, form a large square in the E.

A line supposed to be drawn through Markab and Alpheratz, will pass near *Mirach* (4), in the girdle, and *Almaach* in the right foot of ANDROMEDA, and terminate in *Algenib* (10), in PERSEUS.

Deneb (55), in CYGNUS, is due E. about 62 degrees high.

AQUILA ET ANTINOUS are S. E. by S. the altitude of *Altair* (53) being about 41 degrees.

A line passing through Altair, and the two small Stars on either side of it, will direct the eye up to *Vega* (52), in LYRA; and down to the two principal Stars, in the head of CAPRICORNUS; the latter being 17 degrees high.

The five principal Stars in DELPHINUS, are 9 degrees E. of Altair.

Antares (48), in SCORPIO, is S. S. W. about 9 degrees high.

Ras Algethi (49), and *Ras Alhagus* (50), in the heads of HERCULES and SERPENTARIUS, are near the S. their mean altitude being about 51 degrees.

Libra is near the S. W. part of the horizon; and above it, are the Stars in the head of Serpens.

Capella (12), in Boötes, is in the W. 36 degrees high.

Ursa Major is descending towards the N. W. An imaginary line drawn from *Benetnasch* (39) parallel to *Dubhe* (33) and *Merak* (32), will always direct the eye to *Cor Coroli*, in Canes Venatici.

Capella (12), and its companion in the right shoulder of Auriga, are in the N. being always on the opposite side of the *Pole Star* (0), to that of Vega, in Lyra.

A line passing through Capella and Vega, is nearly at right angles with another passing through the four Stars which form a square in Ursa Major, and the five principal Stars in Cassiopeia.

Leo Major is setting in the W. N. W. *Denebola* (34), in his tail, being only 10 degrees high.

Spica Virginis (38), in Virgo, is W. S. W. but too near the horizon to be seen; and it will not be visible again, in the evening, till April, when it will re-appear in the E. S. E.

If the evenings be clear, and the Moon below the horizon, the Milky Way may be seen extending from Perseus, in the N. N. E. through Cassiopeia, and Cygnus, to the S.

AUGUST.

Aries, the first of the Zodiacal Constellations, is rising in the E. N. E. *Arietis* (6), in his following horn, is 9 degrees high. This Star may be easily distinguished by the two small Stars preceding it, which form a small oblique triangle.

On the N. of Aries, is Musca Borealis; above it, is Triangulum; and S. of it, are a few small Stars in the southern Fish of Pisces.

The large square, formed by *Markab* (59), *Scheat* (58) and *Algenib* (1), in Pegasus, with *Alpheratz* (60), in the head of Andromeda, is in the E. the mean elevation of which is about 30 degrees.

A line supposed to be drawn from Alpheratz towards the N. point of the horizon, will pass near *Mirach* (4) and *Almaach* in ANDROMEDA, *Algenib* (10), in PERSEUS, and *Capella* (12), in AURIGA.

Algol (9), forms a triangle with Almaach and Algenib.

If a line were drawn from Algol to the zenith, it would pass through the five Stars in CASSIOPEIA, and between *Alderamin* and *Alphirk*, in CEPHEUS.

DELPHINUS is S. E. by S. about 38 degrees high; and *Altair* (53), in AQUILA, is between it and the meridian, about 35 degrees above the horizon.

Vega (52), in LYRA, has just passed the meridian, near the zenith; and *Arcturus* (42), in BOÖTES, is due E. at an altitude of 27 degrees.

HERCULES and CORONA BOREALIS, are between Arcturus and Vega.

URSA MAJOR is about N. W. the seven principal Stars being nearly in an horizontal position.

Cor Coroli is about 14 degrees below *Benetnasch* (39), in the tail of Ursa Major; and 14 degrees lower, is the small group of Stars in COMA BERENICES.

SCORPIO, LIBRA, VIRGO, and LEO MAJOR, which are now setting between the S. W. and N. W. part of the horizon, will leave us in the evening after this month. Leo Major will reappear in January, Virgo in March, Libra in May, and Scorpio in June.

The MILKY WAY will appear, every clear evening, extending across the Heavens, like a luminous arch, from the N. N. E. to the S. S. W.

SEPTEMBER.

The four Stars, which form a square in URSA MAJOR, are N. N. W. about 28 degrees high; and the three Stars in the tail, are towards the W.

Alpha Draconis (41), in the tail of DRACO, is in a line with *Phach'd* and *Meyrez*, in Ursa Major.

Cor Coroli is about midway between *Benetnasch* (39), in the tail of Ursa Major, and the N. W. part of the horizon.

Capella (12), in Auriga, is N. E, by N. 15 degrees high, and its companion, in the right shoulder, is a little lower, towards the N.

Cassiopeia is nearly N. E. 51 degrees high.

Between Cassiopeia and the zenith, are the three small Stars in the head of Cepheus; and below it, in the N. E. is *Algenib* (10), in Perseus, 29 degrees high.

Almaach, Mirach (4), and *Alpheratz* (60), in Andromeda, are nearly in an horizontal position, extending from E. to E. N. E. about 38 degrees high.

Arietis (6), in Aries, is below *Mirach*; and a little towards the N. is Musca Borealis.

Algenib (1), *Markab* (59), and *Scheat* (58), in Pegasus, which form the large square, with Alpheratz, are E. S. E. from 30 to 50 degrees high.

The *Pleiades* are rising in the N. E. by N.; and *Algol* (9), is about 19 degrees above them.

Cygnus is on the meridian. *Deneb* (55), in its tail, being about 8 degrees S. E. of the zenith.

Below Cygnus are Vulpecula et Anser, Sagitta, Delphinus, and Aquila et Antinous.

Altair (53), in Aquila, has just passed the meridian, its altitude being about 46 degrees.

Vega (52), in Lyra, is nearly W. S. W. 68 degrees high.

Etamin (51), *Rastaban*, and *Grumium*, in the head of Draco, are about 18 degrees N. of Vega.

Hercules and Serpentarius are W. S. W. *Ras Algethi* (49) and *Ras Alhagus* (50), in their heads, are about 38 degrees high.

Arcturus (42), in Boötes, is W. by N. 15 degrees high; and *Mirach* is about 10 degrees higher.

Coma Berenices is setting in the N. W. Neither this Constellation, nor the beautiful Star Arcturus will be visible in the evening after this month, till the beginning of March.

The Milky Way extends from S. W. by S. through the zenith, to the N. E. by N.; and may be seen every clear evening.

OCTOBER.

Mencar (8), in Cetus, is E. by S. 13 degrees, and *Deneb Kaitos*, in its tail, is S. E. by S. 12 degrees above the horizon.

In a line between Mencar and the zenith, are *Arietis* (6), in Aries, and *Mirach* (4), in the girdle of Andromeda; the former being 37, and the latter 34 degrees high.

Aldebaran (11), in the southern eye of Taurus, is nearly E. N. E. about 9 degrees high; and the *Pleiades* are 12 degrees higher. *El Nath* (14), in the northern horn, is N. E. by E. 11 degrees above the horizon.

Capella (12), and the Star in the right shoulder of Auriga, are N. E.; the altitude of the former being 26 degrees.

Castor (23), in Gemini, is rising in the N. E. by N.

Algenib (10) and *Algol* (9), in Perseus, are E. N. E.; the former being 39 and the latter 43 degrees high. Cassiopeia is above Perseus.

Triangulum is between Arietis, in Aries, and *Almaach* in Andromeda.

Markab (59), in Pegasus, is S. S. E. 51 degrees high; *Scheat* (58), is about 13 degrees higher; and *Algenib* (1), is on the E. 6 degrees lower.

Fomalhaut (57), in Pisces Australis, is near the horizon S. by E.

The three small Stars, forming a triangle in the head of Cepheus, are in the zenith. *Alderamin* and *Alphirk* have just passed the meridian.

Delphinus is S. W. by S. 49 degrees high. A little lower towards the W. is *Altair* (53), and its companions on either side of it.

A line passing through the last-mentioned Stars, will direct the eye down to two Stars of the third magnitude in the head of Capricornus. The same line continued upwards, will pass through *Vega* (52), in Lyra, which is now due W.; and thence to *Etamin* (51), &c., in the head of Draco.

Cygnus is between *Lyra* and the zenith.

Ras Algethi (49) and *Ras Alhagus* (50), in the heads of Hercules and Serpentarius, are W. by S. about 23 degrees high; and a few degrees higher on the S. of them, are four small Stars in the head of Taurus Poniatowski.

Gemma (46), in Corona Borealis, is W. N. W. 16 degrees high.

Arcturus (42), is too near the horizon to be seen.

The Stars in the head of Serpens, are setting in the W. by N.

Ursa Major is in the N. N. W. *Benetnasch* (39), in the tip of the tail, is 22 degrees high.

The Milky Way forms a luminous arch, extending from the N. E. by E. through the zenith, to the S. W. part of the horizon.

NOVEMBER.

The beautiful Constellation of Orion, is just rising in the E. *Bellatrix* (15), in the left shoulder, being 6 degrees; and *Betelguex* (18), in the right shoulder, only 3 degrees above the horizon.

Between Orion and the zenith, are *Aldebaran* (11), and the *Pleiades*, in Taurus; *Algol* (9), in Perseus; and *Almaach*, in the right foot of Andromeda.

Castor (23) and *Pollux* (25), in Gemini, are N. E., the former being 9, and the latter 4, degrees high.

Capella (12), in Auriga, is nearly E. N. E. 37 degrees high; which, with Castor, Betelguex, and Aldebaran, forms a large square of brilliant Stars; extending from E. to N. E.

The five principal Stars in Cassiopeia, are approaching the meridian near the zenith.

Cetus extends from E. S. E. to the meridian nearly. *Mencar* (8), in the upper jaw, *Baten Kaitos* in the body, and *Deneb Kaitos* (3) in the tail, are nearly in an horizontal position.

The principal Stars that are visible in Eridanus, are below Mencar.

At nearly equal distances between the last-mentioned Star and the zenith, are *Arietis* (6), in Aries; and *Mirach* (4), in Andromeda.

Pegasus is on the meridian. *Markab* (59,) and *Algenib* (1), are about 52 degrees high; *Scheat* (58) is about 13 degrees higher than the former, and *Alpheratz* (60), in the head of Andromeda, is 14 degrees above the latter.

Fomalhaut (57), in Pisces Australis, is S. by W. only 7 degrees high.

Altair (53), in AQUILA, is W. S. W. 26 degrees above the horizon. Rather higher towards the S. are DELPHINUS, and the four small Stars in EQUULEUS.

Deneb (55), in CYGNUS, is due W. 61 degrees high.

Vega (52), in LYRA, is nearly W. by S., its altitude being 38 degrees; and about the same height, 15 degrees northward, are *Etamin* (51), *Grumium*, and *Rastaban*, in the head of DRACO.

URSA MAJOR is in the N. *Dubhe* (33) and *Merak* (32) have passed the meridian. *Benetnasch* (39) is N. N. W. 15 degrees high.

Alpha Draconis (41), in the tail of DRACO, is between *Mizar*, in the tail of URSA MAJOR, and the Stars which form the small square in URSA MINOR.

Gemma (46), *Ras Algethi* (49), *Ras Alhagus* (50), CAPRICORNUS, and *Fomalhaut* (57), which are setting between the N. and N. W. part of the horizon, will not be visible in the evening after this month. Gemma will re-appear in the N. E. in March; Ras Algethi in the E. N. E. in April; Capricornus in the E. S. E. in July; and Fomalhaut in the S. E. by S. in October.

The MILKY WAY now forms a continuous stream of light, from E. to W. through the zenith.

DECEMBER.

ORION may now be seen, with all its brilliant Stars, in the E. S. E. A line passing through *Rigel* (13) and *Betelguex* (18) directs the eye to *Castor* (23) and *Pollux* (25), in GEMINI. Another passing through the three Stars in the *Sword*, leads to *Aldebaran* (11) and the *Pleiades*, in TAURUS. If another were drawn through Betelguex and *Bellatrix* (15), it would point out the situation of *Mencar* (8), in CETUS, on the W.; and of *Procyon* (24), in CANIS MINOR, on the E. And if a fourth line were drawn from *Saiph* between Betelguex and Bellatrix, it would pass *El Nath* (14), in the northern horn of TAURUS, and terminate in *Capella* (12), in AURIGA.

Leo Minor, and two Stars of the third magnitude in the head of Leo Major, are near the horizon, in the N. E.

Algenib (10), in Perseus, is 15 degrees E. of the zenith; and *Algol* (9) is about 9 degrees S. of it.

Cetus is on the meridian, and extends from S. S. E. to S. S. W.

Almaach, in Andromeda, is 11 degrees S. S. E. of the zenith; between which, and *Baten Kaitos*, in Cetus, are the three small Stars in Triangulum; *Arietis* (6), in Aries; and the principal Star in Pisces.

Cassiopeia is a little W. of the zenith. *Scheat* (58) *Algenib* (1) and *Markab* (59), in Pegasus, with *Alpheratz* (60), in the head of Andromeda, form a square in the S. W. from 40 to 60 degrees high.

Cygnus is W. S. W. The altitude of *Deneb* (55), in its tail, is 42 degrees.

Vega (52), in Lyra, is 21 degrees high, N. W. by W. More to the N. and rather higher, are *Etamin* (51), *Grumium*, and *Rastaban*, in the head of Draco.

The seven principal Stars in Ursa Major, are from N. to N. N. E.

Altair (53), in Aquila, is setting in the W.; and about 14 degrees above it is Delphinus. These two Constellations will not appear again in the evening, after this month, till June, when they will re-appear in the E.

The Milky Way may be seen every clear evening, nearly as described in the preceding month.

REMARKS ON THE MAPS,

RELATIVE TO

OBSERVATIONS MADE BY THEM IN FOREIGN PARTS.

The Maps will exhibit the appearance of the Starry Heavens, sufficiently near for common observation, to all places lying between the parallels of 50° and 53° north latitude; which comprehends all the southern and midland counties of England, with those of Wales, Munster and the southern parts of Leinster, in Ireland. Also to Holland, the Netherlands, and the midland circles or states of Germany, from the parallels of Bremen, Hanover, and Berlin, to those of Frankfort and Prague. To the midland and southern parts of Prussia, and Poland, from the parallel of Thorn to that of Cracow; and to some parts of Russia, &c.

To the northern counties of England and Ireland, and to the whole of Scotland, the Stars will appear to be removed towards the South; those in the North appearing more elevated, and those in the South more depressed, than they are represented on the Maps. Hence an allowance should be made according to the number of degrees the observer is to the north of London. A similar allowance should be made also at Uranibourg and Copenhagen, in Denmark; and at all the northern parts of Germany, Prussia, and Poland.

At Paris, Rouen, Rheims, and Metz, the Stars in the South will appear rather more elevated, and those in the North a little more depressed, than at London; but the difference will be scarcely perceptible to common observers.

To all the midland and southern parts of France, as also to Switzerland, Austria, and to all places lying in or near the same parallels of latitude, the Stars will appear to be removed more towards the North, those in the South appearing higher, and those in the North lower. An allowance, therefore, should be made, of as many degrees as the place of observation is to the south of London. A like change also will be observed, and for which a similar allowance should be made, at Quebec, New Brunswick, and the southern parts of Newfoundland.

The longitude of the several places will make no material difference in the position of the Stars.

THE END.

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